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OF GLASGOW.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

NINETY-SECOND SESSION.

PRESIDENT'S OPENING ADDRESS.

I.—*Recent Contributions to the Literature of Gold-making.* By Prof. John Ferguson, LL.D., President of the Society.

[Delivered to the Society, 7th November, 1894.]

At the beginning of a new session, I have, as occupying the honourable position of President, to offer you all hearty congratulations at being able to meet once more, and to express the hope that the coming year will be still more productive of good work and fruitful results than any in the previous experience of the Society.

In trying to discharge the obligation which my office entails of addressing a few remarks introductory to the work of the session now begun, I find the choice of a topic for an inaugural address somewhat difficult. The day has gone past for attempting a review of all science, or of even a section of it, by the President of a Society such as this. To say nothing of the impossibility of covering the ground, the necessity for it is done away with by the copious literature at the disposal of any one interested in any branch of knowledge. The journals, week by week and month by month, the transactions and proceedings of societies, and the yearly reports and summaries, not only give all that is wanted by experts, but do so to an extent and with a fulness far beyond the limits of an introductory address. On the other hand, if an attempt be made to give a criticism of some special question connected with one branch of scientific inquiry, it is apt to fail of

its effect by being too recondite, and by the arguments being too remote from the interests and previous study of those to whom it is addressed. Science now has become so specialised that it can hardly make its appeal except to special students. Those who belong to that class can provide themselves with better and fuller information than can be supplied in an inaugural discourse. To those who are not engaged in the study, the questions now of interest to the specialists are altogether beyond their reach. A discourse that would be of interest to the latter would be all but unintelligible to the former. A subject which, while intrinsically technical, appeals to all, interested and non-interested alike, is not so easily caught hold of in these days of recondite scholarship and abstruse study.

I have thought, therefore, when viewing our programme for this evening,* that I might trespass for a little on your time by following in the track of an opening address which I delivered in 1876, when I had the honour of presiding over the Chemical Section of this Society. Seven years before that time, the late Dr. Kopp had published his inquiry into the MS. records of the chemistry of the early centuries of the present era, and I gave a brief abstract of the results at which he had arrived.

I may recall to your attention the then state of the question. Chemistry had, quite certainly, for more than one hundred years, been entitled to claim a separate existence as a science exclusively concerned with certain fundamental properties of matter, apart from all possible applications of the knowledge of those properties. It could look back upon the stages through which knowledge had passed, but it did so to as limited an extent as possible, and it tried hard to forget that there had been earlier and less productive stages. The retrospect was apparently felt to be far from stimulating. There had been centuries of labour, but there was nothing to show for it all. The discovered facts were meagre, the theories had been falsified, and the grand result of all, the hoped-for and ever-promised conversion of other metals into gold, had not only not taken place, but the very notion itself had ended in a mist of words; had become less and less intelligible; had finally vanished away one could not very well say when or how. Those who still cherished the belief in the possibility of such a physical change, kept it to themselves, or communicated it only to those of

* See note at the end of the Address.

like mind with themselves; they gave up all design of influencing the public; they had no hope that they would convince the modern chemists.

The latter, indeed, had no time to consider what had been done so imperfectly by their predecessors, when they found that everything had to be done over again. Neglect of that earlier work was the first result; forgetfulness and ignorance followed. The summing up was, if not a denial of all good in their forerunners, at least a superficial narrative of what little they had done. The common treatment, even by those who professed to describe their work, was contemptuous, and the intention of it was to make the chemists of an earlier period of no account.

I know of no other science in which it has been the custom of professed historians to throw ridicule, instead of striving to arrive at facts and truth. The older historians and scholars assumed that the early attempts to effect chemical change were not only futile, but entirely wasteful. As to the nature of these changes, they held that the views were wrong, and, being so, that it was not worth while inquiring how they originated.

The antiquity ascribed to the science by some, and fairly supported by a certain amount of evidence, was as keenly disputed by others, and the evidence minimised as far as possible. While some maintained the existence of a sage—Hermes, the thrice-great—who was master of all ancient lore, and who originated, or, at least, advanced, the study of nature by the art to which he gave his own name, others denied his existence, and viewed him as nothing more than a myth. Thus, while those who took any trouble about the matter were arrayed against one another in irreconcilable discussions, the chemists went on with what they considered was their real business, the investigation of natural phenomena; and, if they troubled themselves at all about historical questions, threw their weight into the ranks of those who were opposed to the older claims.

If this were a fitting occasion for working out this aspect of the subject to an end, we should find the culmination of the long discussions in the words with which the late Adolphe Wurtz began the historical introduction to his Dictionary, and which, with a stroke of the pen, wipe out all past history:—

"Chemistry is a French science; it was founded by Lavoisier of immortal memory."

If Wurtz's opinion be correct, the task of the historian would

be a simple one, if extensive and laborious. But I fear that, however flattering such a creed may be to its supporters, it will not stand for one moment when the historical test is applied to it. A reply to such an extraordinary statement—utterly wrong even as an oratorical fire-work, but absolutely unjust to previous generations of French chemists, as I myself have shown this Society by examples culled from history during 180 years before there was even the possibility of a Lavoisier—will be found in words that were printed twenty years and more before Wurtz's rash assertion was enunciated. In his chemical letters, printed in English in 1851, Liebig says:—"It is the prevailing ignorance of chemistry, and especially of its history, which is the source of the very ludicrous and excessive estimation of ourselves, with which many look back on the age of alchemy; as if it were possible, or even conceivable, that for more than a thousand years the most learned and acute men, such as Francis Bacon, Spinoza, and Leibnitz, could have regarded as true and well-founded an opinion void of all foundation. On the contrary, must we not suppose, as a matter beyond a doubt, that the idea of the transmutability of metals stood in the most perfect harmony with all the observations and all the knowledge of that age, and in contradiction to none of these?"

Now, if these mediæval searchers after the impossible did nothing else, they did at least commit their notions to writing, as we are in the habit of doing even at the present day. It might appear, therefore, as if there could not have been any great difficulty in ascertaining what their views on various matters were. But here entered certain conditions which seriously influenced such an investigation. The writings were in Greek. That of itself would not have offered any hindrance, but the subject of the writings had to compete in two ways with other writings in the same tongue: primarily, they were concerned with a theme of limited interest, and of attraction to a very few; and, secondly, they were very difficult to understand, both from their theme and from the obscurity of their language.

One can see that if a volume of English poetry or certain plays fell into the hands of a stranger but slightly skilled in the language, simultaneously with some volumes on natural history and physical science, the latter would run the chance of being neglected in favour of the former. This was the state of the case at the revival of classical learning. Much time, in fact the whole

time of scholars, was spent over the remains of Greek philosophy, poetry, drama, and history, while the knowledge of nature, and especially the writings of a later than the so-called classical date, were ignored and forgotten. The writings, however, were not wholly lost or destroyed. Copies seem to have been made in considerable numbers. Some of these, by the natural course of events, drifted into libraries, where they are now; while, doubtless, others perished by fire, by water, by war, and by use.

From time to time, scholars, librarians, antiquaries, burrowing in those libraries, came across these solitary remains of an early science; but, as they brought no real knowledge of the subject with them, and were imbued with the then popular and ecclesiastical prejudice against science in almost every shape, the manuscripts were, if not ignored, treated with the least possible amount of attention and favour. The habit, indeed, was to controvert their ideas, and to disparage their authenticity.

All this research, one would have fancied, might have sufficed to ensure some consideration; but controversy got up, opinions as to the writings were discussed, and the fight waxed hot, not about what *was*, but about what *had been* said. Hardly anyone thought of ascertaining what the writings were about. That was left to one or two, who looked into the matter, but were unable to do anything to dispel the obscurity surrounding them.

Pizimenti, in 1572, was the only one who did anything to make them accessible. He was followed, long after, by Ideler, Gruner, and Bernard, who published part of the original Greek. These isolated portions, however, had no effect; they did not even excite curiosity. The extent of the subject was unknown; its connection with other departments of ancient learning had been entirely lost. The subject had not only ceased to have connection with anything ancient, and still less with anything modern, but it had ceased to be even intelligible in itself, and it was looked upon as the expression of a decayed body of ideas. Those who ever made reference to it at all did so in an entirely sceptical way, as if every point connected with it was in the greatest uncertainty.

Matters were in this position when Dr. Kopp, as I have already stated, published, in 1869, the first part of his "Contributions to the History of Chemistry." It was of this work that I gave a brief account in 1876. It is an admirable research into everything that has been recorded about the Greek chemical MSS.,

with detailed and careful criticisms of the many obscure and controversial matters which rise up in an inquiry of this sort.

The results at which he arrived, though not formulated anywhere, are these:—

1. There are 30 MSS. on chemical questions in various European libraries, of ages varying from the 12th to the 17th century.
2. These MSS. are not identical in contents or in readings, but to all intents and purposes they have a common origin, and contain the same writings of the same authors.
3. The subject is transmutation, a chemical one, to which, however, are added other related, or, at least, other chemical topics.
4. These works are undoubtedly connected somehow with other works which handed on the knowledge to later generations of alchemists, and so on even to the present moment. The books, therefore, are historically connected with the present day.
5. Though none of these MSS. are older than the 12th century, the contents are much earlier, pointing, as some of them do, to the early centuries of the present era.
6. These MSS. do not exhaust all that remains of the early literature of chemical science. There are papyri of even earlier date which contain ideas and descriptions not out of accord with the later Greek MSS.
7. Of all the authors contained in the MSS. the most important is one who passes under the name of Democritus. By the older critics he was believed to be identical with the Greek philosopher of the same name, but that has not been proved, and in all probability cannot be proved.

Upon this question, however, I may interpolate a remark without committing myself to any categorical statement.

Democritus, of Abdera, travelled and studied in Egypt. He became acquainted with the secret lore of that country, and he was also the author of several works about the secrets of nature. The contents of the pseudo-Democritean writings seem to relate to the methods of the Egyptian chemists, so that it is just possible that those writings may, after all, represent some part of the lore which the elder Democritus had acquired. There is, of course, the insurmountable obstacle of difference of language, but while the Greek of the MSS. is not that of 460-360 B.C., it is possible that the original of the contents may have been as old as that, though much modified in later time. All this is, of course, mere surmise. But I can conceive that the Egyptian lore which was taught to the original and genuine Democritus may have struggled on with Democritus' name attached to it till it drifted into the pseudo-Democritean form. Be that as it may, however,

it is equally possible that at the beginning of the present era there may have been a person actually named Democritus, and the confusion may be not of his making, but of those who, not knowing the facts, assumed that there was only one person of the name.

When Dr. Kopp, therefore, directed inquiries into this obscure and neglected subject, he had plenty of material at his command, but it was scattered in all directions, in histories of chemistry, library catalogues, descriptions of MSS., controversial writings, and in treatises where the subject came in in the most casual way. He had to bring these together in the first place, sift and arrange all the disjointed references and allusions, and, hardest task of all, he had to criticise and reconcile conflicting accounts, the inevitable result of human inaccuracy and limited knowledge. No one, who has not tried to arrive at a fact, the golden residuum of truth and reality which is got when all the mud and rubbish have been washed away—I mean the verbiage and erroneous judgments which get heaped up round a simple matter of fact in the course of a few years, and still more in the course of a few hundred years,—no one, I say, has any notion of the difficulty of the labour, the demands that are made on one's temper, patience, keen-sightedness, and numerous other qualities. Kopp had all these, and his book remains a monument of learning and of most diligent search after part, at least, of the truth connected with those writings. He, however, did not see or examine any of the writings themselves, and so he did not attempt to speak as to their contents. He confined himself to what we may call their literary history, and though he may have failed to establish a few details, the work is done so well that it will not have to be repeated unless there is an extraordinary addition to the already existing stores of material.

Dr. Kopp focussed everything that had been said by previous writers. He gave a comparison of the contents of the MSS. and discussed certain incidental questions, and thus enabled future investigators to start with a body of well-sifted facts. The most important general result was the criticism of the unphilosophical position of both earlier and later critics, like Conring and Kircher and others, who refused to investigate the matter at all, because they considered the documents spurious, the authors fictitious, and the subject itself erroneous. Kopp, granting each of these statements to be possibly correct, still

said: the writings are numerous, extensive, and harmonious among themselves; they are not modern; they represent some stage in the progress of knowledge. What do they mean? what are their age, locality, connections? To these questions he attempted only the introduction. This was investigation enough, and he left untouched the further question—What are the writings about?

Twenty years elapsed and the answer to the second question was attempted by Berthelot. In 1888 he published an edition of the Greek chemical MSS. His work consists of three parts: the Greek text itself, based on the MS. in the St. Mark Library at Venice, which is of the twelfth century and is the oldest of all those at present known; a French translation; and an elaborate introduction, explanatory of many things connected with the subject.

I am not going to venture on even the faintest analysis of this book in three big quarto volumes. Such a review as that is out of the scope of my present remarks. I may state, however, that a perusal of it fully vindicates the insight of those older critics, who insisted upon the importance of the MS. records, even if they were wrong as to the support that could be afforded by them to the notion that the study of transmutation was followed by the ancient Greeks. Of this there is no evidence, but it is certain that the ideas were current in Egypt, and some Greeks had adopted them and committed them to writing. The writings are of different dates. There is first, and possibly earliest, the Leyden papyrus; there are the Democritean writings, including Synesius and Zosimus; and then come the later works of Ostanes, Pelagius, Christianus, and many others. These extend over several centuries, perhaps not less than seven. The writings consist of practical receipts for chemical operations, clear enough in certain ways, very obscure in others—either when the writer himself did not understand, or when he wished to conceal his secret from the undeserving. Undoubtedly the work of later Greeks, the writings, or at least the oldest of them, must be held as to some extent revealing some of the Egyptian lore, which drew at an earlier time so many Greek philosophers and inquirers to its schools to be initiated into its mysteries.

The break-up of the Eastern Empire sent these MSS., and possibly some of the men who could interpret them, into Western Europe; but, long before that, the Greek chemical theories and their books had passed to the Arabs, who translated them and

followed their operations. Singularly enough, in the progress of history the knowledge of chemistry came into Europe, not directly from the Greeks themselves, but in a roundabout way by the Arabs. The Western Schools were much more familiar with Avicenna and Rhases, with Calid and with Geber, than with Zosimus and Stephanus, Democritus and Synesius. The Greeks were completely forgotten; whereas the Arabs were translated into Latin, and henceforward all through the later periods of chemical history, their names not only constantly crop up, but no small proportion of the science, down at all events to the middle of the seventeenth century, is really based upon their notions and teaching.

The influence, of course, was felt not only through Latin translations, but by actual schools where Arabic learning was given. Away back in the thirteenth century, and even earlier, Arabic books were being translated into Latin long before there was any word of Greek learning coming to Western Europe.

The chemists, therefore, were instructed through the Arabs, before the earlier Greeks had a chance, and when their books did arrive, the ground, so to speak, was already occupied, their doctrines had been anticipated. The Greek writings, therefore, took no part in the growth of chemical ideas in the West, for Pizimenti's translation seems to have had no circulation, and to have had no influence. By the time it was published (1573) it was long overdue. Geber had been printed 100 years earlier, and the chemists had outgrown any practical instruction that the collection Pizimenti had made could have furnished, and so it passed into the limbo of forgotten books.

As for the Arabs, their language offered even greater difficulties to the chemists than Greek itself. But in MSS. first of all, and then later in printed editions and in Latin, the chemists arrived at what had been done by them. The Arabic MSS. disappeared into libraries, where they have been preserved through the turmoil of centuries. No one, however, has done for them what Dr. Kopp has done for the Greek. The scattered notices about alchemical MSS. in Arabic and other oriental languages have never been brought together, although here and there—in journals, in catalogues, like that of the Escurial, in histories of Arabic literature, like that of Von Hammer, or in the great treatise of Ibn Khallikan, or the history of Arabic physicians, by Wüstenfeldt,—there is much information to be had. Instead of which collection, however, we have the contents of one of the manuscripts now printed.

It was only in 1893 that Berthelot passed through the press an edition of the Arabic alchemical MS. at Leyden, and thus enabled those interested to follow up the progress of the science after the Greek period. Again, in three large quarto volumes, he has given the text, the translation, and an introduction; and once more we are enabled to estimate the notions of previous writers, who have made statements with little foundation in fact.

One result seems to have come out of this publication. The most important of all chemists of the post-Greek period, the chief of the Arabian school, is the person designated in the Latin translations as Geber. He is the author of certain works, "The Sum of Perfection," "The Invention of Perfection," "A Treatise on Furnaces," and his theme is undoubtedly the perfecting of metals into gold. One has always believed that the author of these treatises was an Arab, and that his name was Dschabir Ben Hayyan, Latinised Jabir or Geber. In this belief, so long ago as 1867, in a short-lived journal called *The Laboratory*, I reviewed his life, and the discrepant accounts given of him. Even then I knew of the Arabic MSS. of his writings in Leyden and elsewhere, and hoped the day might come when there would be an opportunity of comparing the Latin treatises of Geber with the Arabic works of Dschabir.

That is now possible, and the very first result is that, apparently, they have nothing to do with one another. The connection is between Dschabir and the Greeks rather than between Dschabir and Geber. I am assuming that the whole subject has been thoroughly exhausted, which I am not quite sure is the case, for it may be that the works of Dschabir corresponding to Geber's are not necessarily those of the Leyden MSS. Dschabir, if we may trust native historians, was a most voluminous writer, and some of his works may correspond with those which have been current in Europe for several hundred years, say from the 8th century, when Geber is reputed to have lived. Berthelot, however, seems to be of opinion that Dschabir's works cannot be identified with Geber's, and he is prepared to consider Geber as post-Arabian, and his writings as of later date. This is an opinion for evidence and criticism, and I am not ready just at the moment to accept it as the only possible conclusion. It may be quite correct, in which case it must be accepted as a new fact in the history of the science in Europe. But there may be something more to discover, and, guided by recent experience,

even in so slight a matter as the date of a printed book, I am not quite ready to fall in with this view.

This, however, I may say, that, if Berthelot be correct—as he possibly is—in distinguishing Dschabir from the pseudo-Dschabir, as he calls him, or Geber, as he prefers to call him, and in discriminating between the Arabic treatises and those in Latin, it does not affect the intrinsic value of the latter, to whatever date in the history of the science they belong. It opens up, however, a new field for criticism and investigation. The first question is, if the Latin tracts are not older than 750, and certainly not later than 1470 or thereby, when they were printed, to what period of the 700 years do they belong? We must now endeavour to find the earliest MS., and earliest form of Geber's works (not Dschabir's) and fix a date for the writing of them. Then we must find out, if we can, how Geber's name came to be prefixed to them. It could hardly be by accident; it might be because the Arabic Dschabir was of so much renown that his name would be of advantage to the book; but if this be no book of Dschabir's, while Geber is a pseudonym, who was the author? The question thus is not shelved by refusing to identify Geber with Dschabir; on the contrary, we have now to determine who was this Geber.

Whoever he was, we may, perhaps, call him, in the meantime, the earliest of European chemists who wrote in Latin, and who gathered his material from those whom he himself calls "the ancients." In Geber's writings one of the features most difficult to explain is the modernness of idea and of expression. There is a practical turn in it which is wanting in the works of others of even much later date, and there is a marked absence of the mysticism which hung around the notions of the writers of the 16th and 17th centuries.

The problems, therefore, which were discussed so hotly in the 17th century, as to the age and origin of the so-called Hermetic Science, are not disposed of even now; but in what a different manner they are discussed—with what very different resources they are investigated! How is it that, although the problem they sought to solve appears to us quite impossible, these documents are treated with an amount of consideration, and studied with a curiosity, which those to whom the contents were of prime importance, neither could nor would have given. The reason undoubtedly lies in the intense interest connected, in the first place, with Egyptian life and arts and science; secondly, in the

passage of that learning into Europe; and, generally, in the modern treatment of archæology as a department of science.

These MSS., emanating from that land of secret science, contain, undoubtedly, the views upon many chemical changes held during an unknown period—shall we say for a thousand years? One cannot afford to neglect such a period as that in the history of any branch of human knowledge. Look at the histories of learning down almost to the present, and you will see that there is absolutely no light anywhere to be found on the history of chemical change, and the ideas of the men concerned with it in the arts, for something like that period.

Thanks to Kopp and Berthelot, we can now get acquaintance with these centuries at first hand, and there can be no longer any excuse for ignoring them; but there are also opened new lines of criticism and research, and the bulky alchemical writings of the late Middle Ages will now have a chance of having their place assigned them. They are undoubtedly the traditions and echoes of an earlier time.

The profoundest ideas and most difficult problems of one age become the ravings of madness or the simplest of conundrums to that age which has no profound ideas of its own, and to which the whole universe is as easy as can be, and all phenomena can be explained by a word or a phrase. But the whirligig of time brings in his revenges, and another cycle comes round when, if the old difficult problems, by all the added light, are not as hard as ever, at least their examination has led to a host of new ones quite as hard, and when it is willingly granted that so far from the universe becoming simpler, it becomes more and more recondite—more and more subtle.

This is very much what has happened with the evolution of this subject. The problems of the early times became foolishness to last century; to us not only do the problems remain, but we have come to take a more intelligent and sympathetic interest in the method of search after truth pursued in times remote from our own, and in countries far removed from our own.

My time is about expended, else I had designed to say a word or two which would connect this topic with that which is now to follow.

Chemistry seems to have begun with gold, with attempts to make it, with efforts to imitate it. The chemistry of the times to

which I have alluded to-night was mainly, if not solely, a gold chemistry; and not merely of those times, but the mediæval chemistry was of the same character. How to get gold, how to make it; its composition, its properties—how to change other metals into it; that was the supreme problem. Many of the receipts of the MSS. seem to refer to the making of yellow alloys, and to producing varnishes which would produce a golden hue. Some of these were in vogue as late as the 16th century, and I have alluded to them, I think, in other papers I have put before you. As long as metals were supposed not only to be compound, but to be compounded of the same elements, so long as it was believed that they were matured in the mines and brought ultimately to the perfection of gold, belief in the possibility, nay, in the unavoidability of transmutation, was inevitable—the theory that gold could be produced was rational on such assumptions, but the degradation of gold was equally conceivable, and a case of it is on record. What led to such a belief in the composition of gold (and of the other metals) would take me more time to describe than I have at present. I cannot help thinking, however, that it must have arisen from certain metallurgic operations. It would take me still more time if I were to describe how it has come about that gold is now believed to be a simple body.

If chemistry seems to have begun with gold, the whirligig of time has again brought in his revenges, for gold has ended with chemistry. That is what we are to hear now.*

* The subject of the paper which followed this address was, "The Profit and Loss of Gold Mining: Ancient and Modern," by Mr. Nicol Brown, F.G.S. In the course of it reference was made to the most recent chemical methods of extracting the metal.

II.—*The Profit and Loss of Gold-Mining: Ancient and Modern.*

By Nicol Brown, F.G.S.

[Read before the Society, 7th November, 1894.]

Synopsis of Paper: — Introduction — Geological Surveys — Mining — Mechanical Operations—Metallurgical and Chemical Processes—Assay Office—Conclusion.

Introduction.

It has been often pointed out that absurd ideas have existed from ancient times about veins of gold and silver which might yet be found as large and as rich as those of the inferior metals. Even such a wise man as Sir Walter Raleigh fell into a snare of the kind when he dreamt of his El Dorado. From age to age, down to the present time, millions of money have been spent by reckless men to find subterraneous golden storehouses.

Nature herself, when superficially studied, may somewhat foster this delusion, as she has scattered nuggety gold about in such a way on the surface as to suggest a great underground store of it imprisoned somewhere in the hills. Geology, however, has taught us the error of this delusive mediæval dream; and the cold material laws of nature, as revealed by this science, tell us what may, and what may not be found.

"When science from creation's face
Enchantment's veil withdraws,
What lovely visions yield their place
To cold material laws!"

We now know that in the processes of denudation of continents, and of building them up again, only some of the gold—and that a very small part—has been distributed as gold dust and nuggets. In the older countries of the world the gold in these forms was rapidly picked up by the first settlers—the store of ancient gold being, of course, mainly derived from those virgin fields.

Gold locked in refractory rock-material, such as pyrites, was practically unattainable by the ancients, and the Mosaic expres-

sion, "And the gold of that land was good," no doubt meant that the gold of the river valley was free, attainable gold.

Such ignorant and avaricious people as have hitherto always been infatuated with gold-mining have gone to work without counting the cost, either for themselves or for others. So largely has this been the case that the great authorities on political economy, who have taken the trouble to inquire into the facts, have often made the statement that gold costs more to produce than it is worth. This arises from gold-mining having been hitherto a very speculative employment; many embarked on it who lost their labour through ignorance, and the average earnings of the gold business have thus been relatively low.

Gold is a durable metal, and the gold now stored in the treasuries of the world is the product of very many past centuries. Much of it was obtained by forced or slave labour, and the cost thereof cannot be reckoned. Some part of the actual gold of Solomon's Temple, of the crowns and jewels of Roman emperors and Saxon kings, may be carried in the sovereigns handled to-day on the counters of any of the banks. It is obviously quite impossible to tell what the anciently-obtained gold has cost.

The business world can no longer afford to pay more for its gold than it is really worth, and naturally no one need now pursue gold-mining as a business enterprise unless gold can be obtained at a price less than what it can be sold for. Nor can the business world afford, as hitherto, to discourage gold-mining because of its speculative character. This paper is intended to show that gold-mining can be raised from a doubtful and speculative to a scientific business.

Men entirely devoid of false ideas in every other business have entered the gold industry with a sentiment of devotedness to the royal metal which, like an *ignis fatuus*, leads them to their doom. There is, however, after all, nothing in this business which promises other than reasonable returns for intelligent industry won by the "sweat of thy face."

In order to demonstrate that profits can be made in gold-mining, it is necessary to define clearly the various departments of knowledge which contribute to the successful mining of gold, and its extraction from the stony matrices in which it is found. By following such a course, the great possibilities of loss which lurk in the business may be observed and avoided, and the ultimate profits secured by those who pursue this industry.

As has been observed, in times gone by, and until recently, the losses have often been larger than the gains—gold-mining enterprises, as a whole, bringing bankruptcy to most of those who have engaged in them. This, however, is now changing.

During the course of the last half-century, while other industries have been developed by science and capital, the industry of getting the gold, necessary and from time immemorial used as a token or representative of the value of the wealth of the world, has, until lately, been largely left in the hands of ignorant speculators.

As a rule, pseudo-geologists or prospectors without adequate knowledge were employed by such men to survey and report on their properties. Incapable persons also have been employed to do the industrial part of the work of mining, of milling, and saving the gold. Meantime the whole world of commerce has suffered in consequence. Indeed, we feel that there is now too little gold in circulation to go the round of the world's currency.

This incapable handling of the gold industry was so patent to the commercial world until quite lately that prudent capitalists avoided gold-mining as an investment.

Even so late as the discovery of the South-African gold-fields, most of the London merchants and financiers declined to go into the business. Consequently, the usual crowd of irresponsible men made their way to the mines, and monopolised the enterprise.

It is believed that there are yet undeveloped gold-fields in Africa and elsewhere, and an endeavour should be made by intelligent capitalists to secure them, so that they may be worked in a proper industrial manner.

When a gold-field or deposit is discovered, the first thing which has to be done is to ascertain whether it is worth working. This inquiry is the province of the geologist and mineralogist, and must be done satisfactorily. It need scarcely be said here that a competent geologist is likely to be an honest one.

The question arises—What is a payable quantity of gold in the ore? Many circumstances enter into the calculation, and to give a general answer as applicable to all mines would be misleading. Always reserving, however, inquiry into the special conditions of each case, this may be said—namely, that ore carrying one ounce of gold to the ton is, under ordinary circumstances, a profitable subject for treatment.

After the geologist comes the mining engineer, who opens up

the mine in the lode or deposit in such a manner that it may be worked in the most economical way. Then follow the operations of the mechanical engineer, who erects the mills for crushing the lode stuff. Next comes the amalgamator, or chemist, who extracts the gold from the ore.

In rocks containing gold the precious metal is usually disseminated through the whole mass; and an idea of the searching character of the work necessary to get an ounce of gold from the ton of ore may be formed by remembering that there are 32,666 troy ounces in an avoirdupois ton of sand, clay, and gold, which have to be ground up and sorted out, or otherwise dealt with, to get from it the one ounce troy of gold. The proportion of gold contained in a ton of such matter is ·00306 per cent., or $\frac{1}{32666}$ of the whole. This shows what delicate operations are required to save such small quantities of gold.

In order to realise in some degree the extent of this sorting-out in actual practice, imagine 32,666 pieces like lump sugar of the ordinary cube size, and remember that in each of these cubes there may be a minute piece of gold. To get at these small particles, all the 32,666 pieces have to be ground up, and the result of all the necessary operations only extracts such a small quantity of gold as to be equal in size (leaving out of account the relative specific gravity) to a single one of the cubes.

For comparison, let it be noted that in the copper industry usually about 150 lbs. of copper are recovered from 2,240 lbs. of ore, and that in the iron industry about 1,120 lbs. of iron are recovered from 2,240 lbs. of ore, so that any one can at once see the relatively small amount of gold extracted from the amount of ore handled, compared with the metals extracted from other ores.

Owing to confusion arising in the minds of unskilled persons as to the proper administration of gold-mines, the work of the different departments has often become hopelessly mixed. By such persons the manager is expected to be a geologist, a miner, a mechanic, a chemist, and a business administrator, all rolled into one; but evidently this leads to failure.

In order to make clear the scope of the work of each scientific man in his own department, and how much cash the business administrator can allow to be spent on it so as not to exceed the limits of a safe average cost of production of an ounce of gold, the departments will be treated under the following separate heads:—(1) Geological, (2) Mining, (3) Mechanical, and (4) Metallurgical.

Over all these there should be a general manager, technically trained to this or a similar business, assisted by a competent assayer, to check the various operations at their different stages.

1. The Necessity for Geological Surveys by Competent Persons.

A general and exhaustive study of the geology of gold-bearing veins and strata is necessary to successful gold-mining, otherwise the whole subject remains shrouded in uncertainty. Proper geological surveys must take the place of the old prospector's empirical work, in order to prepare the field for the tools of the workers of the mines, who cannot otherwise proceed intelligently with their operations.

The face of nature, which, in olden times, appeared mystical and incomprehensible, is now unveiled, and may be seen and known by those who seek her earnestly. The result is, that we look for no subterranean deposit of nuggets, but only for the "mineralised" or metal-bearing beds of rock, which must be worked industrially before they yield up their treasures. When the "alluvial" fields of California and Australia were first discovered, it was only the nuggety gold which was sought for amongst the river sands, and the value of the hard rocks was not thought of.

If we refer to the annals of these gold-fields, it will be found what a terribly wild speculation this gold-finding proved to be. Stories of the wonderful finds of those days linger in the memory of people still living. Wild, lawless, uncontrolled men flocked to those countries from every part of the world to make their fortunes in a day; and in extravagance and debauchery the majority spent it as fast as they had gained it.

It was slow work, after the subsidence of that gold fever, for a legitimate gold industry to establish itself; yet such an industry did spring up in California and Australia. Its development, however, was slow, and the early result of the mining and milling of gold-carrying quartz rock was not encouraging.

Too great haste has been often shown by the so-called "practical" man, whether capitalist or miner, to get at the gold, his only chance of profit. Such men always defeat the object they have in view; for it is only a proper understanding of the way in which gold is locked up within the gravel, or the sand and clay, the product of the stamps, that leads to a comprehension of the true method of obtaining gold cheaply, at a rate which will offer

profit to capitalists. Briefly, it is the proper handling of these hard or intractable substances which will render it possible for any one to win the gold from their embraces. It is, therefore, necessary to understand in some degree the distribution of gold as seen in nature.

Gold is found in very small quantities disseminated through the mass of granitic mountains; but to grind up such mountains for their gold would, of course, be a costly and unremunerative operation. It is locally distributed in many alluvial deposits, and it is also found in sea-water, in the proportion of about one grain to the ton.

Earth-movements, which have been going on from the earliest to the latest geological times, have caused great fissures in the earth's crust. Many of these fissures descend to unfathomed depths, and have formed vents or chimneys for the escape of gases and steam, carrying dissolved and vaporized metals, including gold. These vapours were condensed, and the solutions were deposited in these fissures and cracks; and the solid contents of these now form the lode-matter of mineral veins, so often pyritous and containing gold. In a group of such veins it often happens, however, that only a few are auriferous. Many cracks and fissures may also have been filled up by infiltrations, by the rain-water of the surface carrying vein-matter containing gold denuded from the mountain sides.

Geologists have taught us that during the long course of ages the mountains have been disintegrated and worn down by rain, snow, frost, and by river and sea action; and the quartz, felspar, and other minerals, which are their principal constituents, have been laid down on sea shores and bottoms as gravel, sand, and clay. Piled up in massive beds, they formed in time conglomerates, sandstones, and mudstones, and were afterwards elevated by earth-movements and built up into solid lands and mountains. It is in this way that the great geological writers point out how the gold and other mineral contents of the rocks have ever been travelling along with the pebbles, sands, and clays, for countless ages of time; and, shifting from mountain to plain, and from plain to sea, they have been crushed, crumpled, and metamorphosed by pressure, heat, and chemical changes, resulting from repeated earth-movements; and thus the gold, having been segregated and concentrated, is found in quartz and other veins in these newer formations.

To follow these natural interchanges and results intelligently aids us to find out the general direction of the ore bodies as they lie in the earth's structure.

Pyritous ores lying in any position near the earth's surface, and above the level of the water carried in the rocks, absorb oxygen to combine with their sulphur, and thus become more or less iron oxides and sulphate of iron. Pyritous ores in deeper places below the water-level retain their sulphur, and from such ores it is always difficult to extract the gold. The former are generally classed as free-milling ores, the latter as refractory.

The deposition of gold with conglomerates, sandstones, and schists, which have arisen from the destruction of older rocks, represents one class of auriferous deposits.

Still newer and more recent deposits with gold are represented by gravel, sand, and clay, worked out of old rocks, and laid in river terraces and bottoms of valleys. In California and Australia the river beds in many cases have been filled up with lava flows, forming a crust over the gravel, and so the auriferous deposits have been protected from subsequent denudation. It appears that the largest amount of gold obtained by the world's working has been derived from sedimentary rocks, comprising both alluviums and old strata.

Further detail on the question of the origin of the geological conditions of gold-bearing deposits need not here be given. Enough has been said to show that the study of the nature of the enclosing matter, of the quartz and felspar rocks, or of the derivative gravel, sand, and clay, is an essential part of knowledge required by those engaged in the gold industry.

The geologist and mineralogist not only prepare the way for the miner, but also for the gold-extractor, because a preliminary knowledge of the chemical and physical conditions of the ore body enables the owners of mines to erect extraction works suitable for the saving of the gold found under the peculiar circumstances of each case.

As an example of the kind of geological work which should precede any attempt at mining, let the reader procure the special geological reports on particular gold-fields—such as Mr. E. J. Dunn's "Report on the Bendigo Gold-Fields of Australia," or Mr. A. R. Sawyer's "Report on the Mashonaland Gold-Fields"—and it will be seen how variously nature has worked in each case, how carefully and cunningly she has hidden away her golden treasures

in the folds of her garment, and how these treasures can only be found out by a painstaking study of the geology or physical structure of the earth. Such reports, had they existed only a few years ago, "would have saved enormous waste of time, labour, and lives." They are evidence that a better state of things is growing up in the gold industries, while the handsome dividends paid by some of the great gold-mining companies show the profits which may be derived from a careful working of the business based upon intelligent and scientific treatment.

Mr. Harry Page Woodward's "Mining Handbook to the Colony of Western Australia" is another great advance in the dissemination of valuable scientific knowledge; and it has this great merit that it has been published well in advance of the general rush to these gold-fields. It has been written by a very competent man, and is prepared expressly for prospectors and strangers to the colony who are interested in mining. It will thus supply many a hard-working man with a scientific "*vade mecum* which will surely help him to do his work with less toil and more certain purpose than ever could have been dreamt of in the days of former "gold rushes." Instead of the ignorant cackle of the mining canteen, where prospectors have usually picked up their scraps of information, they have here the well-digested hints of an able geologist; and it argues well for the future of Western Australia that the van of the prospectors has been led by Mr. Harry Page Woodward.

The "life" of a mine should be carefully estimated. This is too seldom done by the miner, though the Stock Exchange marks its sense of the necessity for this by quoting the shares of any mine lower after it has paid a dividend, as they say the mine is so much the poorer. This is a crude method, however, and has no lasting practical result, as many regular dividend-paying mines gradually increase in value, and their shares are sold at large premiums.

The vocation of what we may term the geological actuary has evidently yet to be defined; his duty would be to investigate the probability of the continuance of good ore in the mines. The costs of preliminary and concurrent surveys by competent geologists should always be provided for in any gold-mining scheme. The expense of such surveys will be infinitesimal compared with the money thrown away in times past on abortive El Dorado-like schemes.

2. Mining.

The mining operations should be under the control of an educated and experienced mining superintendent. He must be a practical working miner, and should have had experience in mining various ores in different parts of the world. It is a great disadvantage to employ a miner whose prejudices have been developed by long experience in one particular series of rocks or of the physical structure of one country. Such a man, however capable otherwise, has no resources when he comes to deal with new geological conditions. Unfortunately, many good mines have been condemned by such men.

Having considered the distribution in nature of rock-matters carrying gold, the cost of bringing these auriferous ores "to grass," and their delivery to the mills for the extraction of the gold, should now be investigated.

The various methods of gold-mining naturally depend on the formation of the gold-bearing rocks. In some mines the ore is won through vertical shafts by winding machinery, and in others by inclined shafts or horizontal tunnels, in which tramways are worked by endless ropes. When the ore bed lies near the surface, it is sometimes found convenient to strip off the superincumbent mass of earth, or "overburden," and work the ore bed as an open quarry. The river banks or terraces containing auriferous gravel and sand are "hydrauliced"; that is to say, the banks are washed away by powerful jets of water, and the gold is saved by catching it in boxes containing mercury placed along the bottom of "flumes."

All these methods open vast fields for the exercise of mining-engineering skill and enterprise. The commercial success of the venture depends as much on the proper development of the mine as on the actual gold contents of the ore.

With ore carrying not more than one ounce of gold to the ton, the cost of mining and delivering the ore at the mill should, in no case, exceed 12s. per ton.

3. Mechanical—Crushing the Ore.

Having followed the ore "to grass," as the miners call the surface, and delivered it to the mills, the next work to be done is to crush it fine enough to liberate the particles of gold. This is done by passing it, first, through a stone-breaker, in which the

larger pieces are reduced, and then by crushing further in a stamping battery or other pulveriser.

The battery, as well as the preparatory rock-breaker, should be under the care of a practical mechanical engineer. It is not necessary that he should have had formerly much experience in batteries; but it is necessary that he should know the wearing qualities of different metals used in the battery. The battery is usually a mechanical arrangement of heavy hammers, which fall from 80 to 100 times per minute, and the iron heads of which are subject to enormous tear and wear. The chief subject for the consideration of the mill superintendent is the life of the wearing parts of the mill.

The battery is flushed with water, and the finely-divided ore (or "pulp") is carried through the gratings at the stamps and on to copper plates covering a table, over which it flows in a broad, thin stream. The surface of these plates is coated with mercury, which forms an amalgam with most of the larger particles of free gold while passing over the plates. The amalgam is scraped from the plates at intervals, usually of a month, and heated in a retort so as to separate and recover the mercury and the gold. This operation is called the "clean up." Unfortunately, all the gold is not caught on the plates, but a large percentage is carried away in the tailings of sand or clay, or in the water; and at this point, again, a knowledge of the enclosing rock-structure, and of the chemical and physical condition of the material carrying the gold, is necessary for success in saving this metal.

If the "gangue," or stony matrix of the gold, is felspathic in character, the felspar is reduced to clay by the stamping; and the water flushing the mill first deposits the sand of the quartz in the water channel or "launder," at the end of the tables, carrying off the clayey or flocculent matter to a greater distance. This separation of sand and clay increases the difficulty of the after-treatment of the tailings. With the sandy tailings there is a chance of recovering some of the gold by working them over again; but with the clayey tailings or "slimes," as they are called, it is difficult to deal. There is no greater "thief of gold" in the mill than the clay. Take a ton of clay from a brickmaker's clay puddle, such as can be seen any day, add to it half-an-ounce of gold dust or gold leaf, and imagine the difficulty of recovering the gold from such slime.

The water used for flushing the mill is also a robber of gold.

When the stamps used in crushing the ore strike very small pieces of the contained gold, they convert these into gold leaf. This gold leaf is called "float gold," as it is apt to float away with the water, and so escape the possibility of being caught either by the mercury, or by any other process of extraction.

Where water power or cheap fuel is available, the cost of milling the ores may be set down as 6s. per ton; and, if operations stopped at this point, it would mean that 18s. had been spent in obtaining, say, 30 to 40 per cent. of the contained one ounce of gold per ton, or equal to 6 to 8 dwts. of gold, worth 25s 6d. to 34s. Unless for operations conducted on a very large scale, this is, as a rule, too small a margin to pay charges on capital and general expenses. By grinding the tailings in pans with mercury, and by other expensive contrivances, at a cost of, say, 8s. per ton, a further yield of 10 to 20, or, perhaps, 50 per cent. altogether, may be obtained.

Mechanical and amalgamating methods may, with some special free-milling ores, get a very large extraction, but generally the result does not exceed the 50 per cent. just stated.

A *résumé* of the extraction would be—milling and amalgamation, 30 per cent., equals 6 dwts., plus pan treatment of tailings, 20 per cent., equals 4 dwts. Total extraction equals 10 dwts.

A *résumé* of the cost of the mining and extraction of the above 50 per cent. would be—mining, 12s.; milling and amalgamation, 6s.; say, pan treatment of tailings, 8s.—total cost, £1 6s. Value of 10 dwts. of fine gold equals £2 2s. 4d. Profit, 16s. 4d.

The figures of costs given above may often be reduced, but should never be exceeded. If they are exceeded, something must be wrong with the arrangements of the mines or works that calls for explanation. These *pro formâ* costs are applicable, as a whole, principally to mines carrying an ounce of gold to the ton of rock. It is believed that there are vast deposits of such rock. The costs are not applicable, as a whole, to other varieties of gold-mines, such as those carrying many ounces of gold to the ton, or where the gold is found in combination with silver.

A precarious profit of 16s. 4d. per ounce of gold obtained represents the stage reached a few years ago by ordinary mines before the introduction of the chemical process of extraction of gold to be subsequently described. A few favoured mines made more profit than that just indicated, but the greater number had a hard struggle for existence.

As the profit shown for one-ounce ore, as already defined, presents too small a margin to pay general expenses and capital charges, and yet leave sufficient for the contingencies to which all mining properties are more or less liable, mine-owners have long looked for a process capable of extracting the 50 per cent. of gold usually left in the tailings of sand and clay. In the hope of such a process being discovered, many mine-owners have for years past stored up their tailings for future treatment; and those who have done so are now reaping the fruits of their prudence, as within the last year or two a chemical process capable of recovering 80 to 90 per cent. of the gold has been brought into extensive operation, thus extracting a very large percentage of the contents.

The Californian stamp mill for crushing the ore was an improvement in details and adaptability on the old Cornish mill used in tin stamping, which has been in vogue since the seventeenth century; and around the crushing machinery there still cling too many antiquated methods.

The catching of the gold on copper tables has been and is even now under the care of an officer, usually called an amalgamator. A good amalgamator, diligent at his work, and strictly honest and sober, might, by the exercise of a keen observation and acquired experience, after many years, be able to improve the savings up to 30 or 40 per cent. of the gold contained in the ore. This, however, could only be obtained by long and special experience, and as the result of his empirical method of saving the gold. Such a man was always difficult to obtain. He was more an artist than a workman, and represented the type of man employed in the process of refining copper in the Swansea furnaces, and whose precise method science has not yet been able to define.

A similar type of person, in a different employment, was the old-fashioned dairymaid, now long retired to the moorland farm, if not wholly extinct. She tested the progress of the operation of cheese-making by the taste. If her palate was true and clean, she made good cheese; if not, the cheese was spoiled. In this rustic industry, also, science has replaced the old by new and different processes. Nowadays the operation is regulated by readings of the thermometer.

All empirical methods of working any business must eventually give way to scientific systems. It is evident that until quite recently the gold industry has been left far behind in the march of improvement. The history of abortive processes of gold-saving

is a veritable record of struggles in the Slough of Despond. If any one will refer to Lock's excellent book on "Gold," he will find there a long catalogue of processes which, though suggestive, are not practical in their application. The only process which was partly successful was the grinding of tailings in pans, as formerly indicated.

At this point it may be mentioned that mines are often situated where there may be sufficient water for washing the ore, but where there is not sufficient fall in the water-level to supply power to drive the mills, and where the other source of power, fuel, is scarce. Until recently such mines could not be worked at a profit unless the ore was exceptionally rich, but electrical science has made such strides within the last few years that power generated by a water-mill at a distance of many miles can now be transmitted by cables, and utilised at mines or mills with a comparatively small percentage of loss of efficiency in transmission. The result is that operations formerly impracticable can now be carried on at a profit.

4. Metallurgical and Chemical Processes.

The origin of modern chemistry springs from the searchings of the alchemists, whose aim was principally to make gold out of some other metal. It is strange that, while the ancient chemist devoted so much attention to gold, the modern chemist, until recently, left it severely alone; and, even though scientific chemists have now become alive to the importance of their science in its application to gold-extraction processes, the commercial and so-called practical men in charge of mines, as a rule, do not see its full importance. In some parts of Australia and elsewhere, even yet, it is the exception to employ chemists, with the result that the gold lost in the tailings is left untold and unestimated.

Every metal-extracting works for gold or other metals should have a good practical metallurgical chemist, accustomed to work processes on the commercial scale.

The limitation of amalgamation by mercury to free-milling ores has caused gold-miners, as afore-mentioned, to look out for other methods of extraction. Smelting could only be profitably resorted to when the ores were extremely rich, as it would require too much fuel to do the work for poor ores.

Many chemical processes have been suggested and patented, but practically only two such systems have been successfully

worked—namely, the "Chlorination" process, and the "Cyanide" process. The ores and tailings that are not amenable to amalgamation may generally be classed as sulphides, or as containing sulphides, with which the gold is in so intimate connection that it is difficult to attack the gold without at the same time attacking the sulphides, and so using an excessive quantity of the chemicals.

Chlorination.—In the case of treating the ores by chlorination, it is usual, in the first place, to take out as much of the free gold as possible by amalgamation, and then to concentrate the tailings by some mechanical means, such as by Frue Vanners, which sort the rich ores from the poor by specific gravity, thus reducing the bulk and increasing the assay value from a low produce up to from 5 to 20 ounces of gold per ton of concentrates. These concentrates are then calcined, the sulphides of the base metals present being changed to oxides. Most of these latter have no affinity for chlorine. These calcined ores or concentrates are then put into revolving drums or barrels, and subjected to the action of chlorine gas. The chlorine dissolves the gold, and the gold solution is washed out of the ore into tanks. Here sulphate of iron is added, which precipitates the gold, and the waste liquor is drained off. The precipitate is collected at intervals, and smelted into bars.

The original and still popular method of chlorination is the "Plattner," in which the calcined ore is placed in vats with a perforated false bottom. The chlorine gas which is intended to act on the gold is introduced between the true and false bottoms, and penetrates upwards through the porous ore.

Later modifications of this process are known as the "Mear's," the "Newbery-Vautin," and the "Pollok." These consist in putting the ore in revolving drums, and allowing the chlorine to act under pressure. The pressure resulting from the generation of the gas itself is utilised in the Mear's process, air pressure in the Newbery-Vautin, and hydraulic pressure in the Pollok, to bring the chlorine into more intimate connection with the gold.

Generally speaking, the chlorination process is expensive, and can only be adopted when the ores are comparatively rich, and where fuel is sufficiently plentiful to allow of calcination being effected.

It is difficult to arrive at any average cost of the chlorination processes, as these processes are so much in the hands of Custom Works, whose interest it is to say as little about costs as possible. In the United States, where chlorination is the favourite chemical method of treating refractory ores, the charge made by

Custom Works for treating concentrates is about $18 to $20 per ton, or, say, £3 10s. to £4. Nearly the half of this rate may be taken to represent profit, as the average cost of six mines treating their own concentrates works out $12, or £2 10s. As far as can be gathered, the cost of concentrating is not included in any of the above figures. In Australia, Custom Works charge about £3 per ton.

Concentrates treated by this process may run from 5 ounces up to 20 ounces and more per ton, and the richer the concentration the better percentage of extraction seems possible. To make a proper comparison of the costs of this with other processes, the costs of concentrating should be known and added to the above figures, and the total divided by the number of tons from which the concentration has been made.

The Custom Works guarantee a return of from 90 to 95 per cent. of the assay value of the concentrates; but this must not be mistaken as the percentage recovered from the tailings; for it must be remembered that mechanical concentrators are far from perfect in their action, and allow a considerable amount of gold to pass away uncaught.

Concentration and chlorination should, therefore, be judged as together forming one process, the costs added and referred to the original ton of tailings, and the product stated as the percentage (recovered by chlorination from concentrates) of a percentage (recovered by concentration from crushed ore or tailings, as the case may be).

Cyanide Process.—This is the most recent of all the chemical processes now in practical use, and, considering the short time that it has been in vogue, it has had an extraordinary influence on the gold industry in South Africa and other places. The process is applicable to most of the refractory ores and tailings, and one of its main advantages, besides its economy, is its simplicity, though where there is much copper the expense is considerable.

The ore, having been ground to a given fineness, without any preliminary roasting, is put into large vats, of a capacity, in some cases, of 200 and 300 tons, and in these it is treated with a weak solution of cyanide of potassium. This dissolves the gold. The auriferous liquor is then run through boxes containing zinc in a fine state of division; and the gold is precipitated on the zinc, from which it is washed off at intervals. The mother liquor is pumped back to the supply tank, brought up to its original

strength, and used over again. This process is known as the "MacArthur-Forrest."

It was long known that the cyanides had an affinity for metallic gold; but, as they had also an affinity for the baser metals, the extraction of gold from ores by this means was not considered feasible. Mr. MacArthur and Dr. Forrest, however, discovered the interesting fact that "cyanide" in certain conditions had a strong selective affinity for gold, and that, by utilising this and employing weak solutions, the economical recovery of gold from ores might be accomplished. The zinc used as the precipitant is in the form of filaments or fine shavings, prepared from the metal in a lathe, and pressed together to form a spongy mass, with a maximum of bright surface for a given weight.

No attempt has been made in the foregoing description to enter into detail, but simply to give a general outline of the process.

The work is done by an expenditure of cyanide of potassium roughly equal to about 10 per cent. of the value of gold recovered. The cost of the cyanide is about 4s. per ton of ore treated, and the other costs are the labour of charging and discharging the tanks, and of pumping up the liquor to circulate it again. This may be taken at about 4s. per ton. By this process, used as an adjunct to the amalgamation already in use, an additional 8 dwts. of the gold originally contained in the ore may be recovered, making, in all, a recovery of 90 per cent. of the contained gold. At an expense of about 8s. per ton, therefore, a further value of £1 14s. worth of gold, or an additional profit of £1 6s. per ounce, is obtained more than formerly.

The total profits under this improved system of gold-extraction amount to about £2 2s. 4d. per ounce of gold produced, exclusive of capital and general charges.

The Tables No. 1 (Mining) and No. 2 (Milling) show the principle on which the respective figures of costs have been chosen. Table No. 3 exhibits a summary of the costs and gold produced from one-ounce ore. (See pages 34 and 35.)

By taking, as has been done throughout these calculations, one ounce of gold to the ton, a datum line is established from which further investigation may proceed. It is believed to be a figure generally applicable to vast masses of rock, and thus helps to show that for these ores there is a large and profitable field open to scientific and business enterprise, which lies well outside of the pale of hazardous speculation.

The cyanide process, as it at present stands, labours under a drawback, which will be cured in the near future. It will be observed that in the wet-stamping process which has already been described, the water is used as a carrier of the small ore for the purpose of distributing it over the tables, and has the effect of separating the sandy from the clayey tailings, and also of carrying away in the water the float gold, which is probably lost beyond recovery. This part of the operation, which, while suited to some extent for the amalgamation stage of many processes, is entirely unsuited for the MacArthur-Forrest process.

It is found that the flocculent clayey tailings consolidate into hard and impervious masses which defy percolation; but if the sand grains had not been separated from the clay, they would have kept open channels for the percolation of the cyanide liquors. It is apparent, therefore, that the process of separating the sand and clay into two varieties of tailings is a mistake, if a percolation process is to follow.

Yet it is by the ordinary and more or less unsuitable plant and methods that the great results of the cyanide process have been obtained. Most of the companies that have adopted the process had their mills already erected, and it was, of course, difficult to change the plant until it was worn out, and it had been proved that another method of crushing was better.

A method of dry-crushing the ore seems to be the best adapted for this process, and when this shall have been carried out practically, and the dry-crushed ore treated directly with the cyanide, without the use of mercury-covered plates, it is hoped that another stage may be reached in the profitable saving of gold.

Siemens-Halske Process.—Very recently one or two mines in South Africa have adopted the Siemens-Halske process of gold recovery. This is a modification of the MacArthur-Forrest process, but whether or not it is an improvement remains to be seen.

It starts with the treatment of the tailings by a dilute cyanide solution in large tanks, as in the MacArthur-Forrest process; but, instead of the precipitation of the dissolved gold being effected in boxes filled with zinc shavings, it is effected electrolytically. The solution is passed into large tanks filled with cathodes of sheet lead and anodes of iron, the weak cyanide solution forming with the dissolved gold the electrolyte, which is kept in circulation by pumps. A current of about 4 volts and ·06 ampere per square

foot is used, and the gold is deposited on the lead sheets, which are removed at intervals, melted into ingots, and then cupelled. The iron anodes, of course, have to be replaced, as they are gradually consumed, forming, with the cyanide, Prussian blue. At the Worcester mine it is claimed that the costs by this process are three shillings per ton, exclusive of royalty; but the process has scarcely been working long enough, nor have sufficiently independent figures been published, to enable one to speak confidently in regard to this.

Amongst the recent literature which may guide mine-managers in some of the subjects which have been considered in this paper, mention may be made of "Curtis on Gold-quartz Reduction," a paper read before the Institution of Civil Engineers in 1892; "Louis on Gold-Milling" (1893), in which the costs of numerous mines throughout the world are detailed in tabular form; Abraham's "New Era in Witwatersrand Gold-Fields" (1894), in which the average product of the ore of the district is given as 14 dwts.;—this, however, is only the product, and not the contents of the ore. It is better to deal in practice with the gold contents of the ore, and not the gold extracted from the ore, as, unless this is done, the probable losses in process always going on are never discovered.

Mr. Abraham gives the average cost of working in the Witwatersrand district similar to that in the tables mentioned above (page 34). There are some differences of detail, but they nearly approximate. The profits are less by his calculations, because the product is only 14 or 15 dwts., whereas in the foregoing calculations the product is 18 dwts. per ton of ore.

Mr. Abraham's book is, however, very valuable to all interested in Witwatersrand mines, as it gives the dip of the reefs and methods for approximately calculating the life of a mine in that district.

Mr. Abraham also draws attention to the celebrated report of Mr. Hamilton Smith, published in the *Times* in January, 1893. That report led to the Prussian Government sending out a mining commissioner, Herr Bergrath Schmeisser, who remained at Johannesburg four months, and who came to similar conclusions as those of Mr. Hamilton Smith as to the great extent of the Witwatersrand deposits.

The MacArthur-Forrest process was first successfully put into practice in South Africa in 1891, and has since come into use in

most gold-producing countries. Its most extensive use is still however, in South Africa, where about 30 per cent. of the total gold output is the result of the cyanide process.

The actual out-turn of bullion by the process since its commencement in South Africa is as follows :—

1891 (3 months),	- - -	17,332 ounces.
1892 (12 ,,),	- - -	178,108 ,,
1893 (12 ,,),	- - -	350,213 ,,
1894 (7 ,,),	- - -	383,960 ,,

The Assay Office.

This office should be under the direct control of the General Manager. An account should be kept showing the assay value of the total fine gold contained in the ore before it is milled, and of the fine gold produced therefrom. The difference unaccounted for should show the gold unrecovered in working the process—that is to say, the gold left in the spent ore, usually called the tailings of sand and clay, after full treatment.

When the amalgam of gold and mercury is taken from the copper plates, it is brought to the assay office and retorted. The mercury is distilled off, and the gold is left in the resulting bullion. This is cast into ingots of about 250 ounces weight, and sent, after being refined, to the Mint. So, also, the precipitated gold from the cyanide solution is scraped off the zinc, fused, and cast into bullion, its ultimate destination being also the Mint. The bars are assayed before being sent to the Mint, and are reported as being so many parts fine, 1,000 parts representing absolutely pure gold. The bars from amalgamated gold usually run about 800 to 900 parts fine, according to the ore treated. The remaining parts of the 1,000 may consist of silver, copper, or a little iron. An appreciable quantity of silver in the bullion is paid for by the buyers. Nothing is usually allowed for the other metals. The bars from cyanide-extracted gold are usually low in value, running about 600 parts fine gold in 1,000. The impurity is principally zinc or lead from the extractor boxes.

The gold carried in the bullion when sold in London is at a fixed value. The value of standard gold (22 carat) is fixed by the Bank Act of 1844 at £3 17s. 9d. per ounce, and this has been nearly its value since the beginning of the eighteenth century; before then the value was less. The value of pure gold (24 carat) is therefore £4 4s. 9¾d. per ounce. A mining company possessing

ore bodies which contain one ounce of pure gold to the ton, and from which they can obtain, as has been shown already, about 90 per cent., or 18 dwts., of pure gold, will have in hand £3 16s. 4d. wherewith to pay all expenses incurred from the auriferous ore to the ingot of gold, and leave a profit.

CONCLUSION.

The certain market at a fixed rate for the product of gold-mining is an advantage which other metallurgical industries have not, and removes all fear of falling prices, which is the constant disappointment of all other industries. The cost of producing the world's supply of other metals approaches the market value of these metals, and leaves little or no margin of profit to the producer. Year by year prices of all commodities sink lower and lower, and only those few producers who can improve their processes and reduce costs manage to make any profit.

If some of the energy, capability, and capital devoted to other metallurgical industries were devoted to the production of gold, substantial results would follow. In those industries so keen has been the competition that every item of cost is foreseen and allowed for; and this is all we ask should be done for the gold-mining industry.

When the fair offers of profit are considered which nature and science hold out to the industrious and intelligent gold-miner, the question may be put—Will there not some day be a deluge of gold? Such questions arose when the Australian and Californian gold-fields were producing the large quantities of nuggets, and the output of South Africa and Western Australia suggests the same question to-day. It is not, however, probable that gold will be greatly depreciated in value relatively to silver, as it is restricted in its native distribution; and, moreover, it is so uniformly distributed in such very small particles throughout the rocks that great industry and intelligence are required to gather it into a compact form.

Murchison points out, in connection with this, that argentiferous lead expands largely downwards into the bowels of the rocks, and suggests that it must yield enormous quantities of silver for ages to come. He then picks out the aphorism in the Book of Job, in which the natural truth is clearly expressed—

> "Surely there is a vein for the silver,
> . . . the earth hath dust of gold."

TABLE I.—MINING COSTS.

References.	Page.			£ s. d.	£ s. d.
Abraham,	13	Average of 84 South African Cos.			
		Mining Developments, -		0 4 8	
		Mining only, - - -		0 13 0	
				———	0 17 8
Mineral Industry—					
Vol. I.,	222	Alaska Treadwell.			
		Mining Improvements,	$0 93	0 3 10	
		Mining only, - -	$0 63	0 2 7	
				———	0 6 5
Vol. I.,	223	El Callao.			
		Prospecting and Improvements, - - -	$8 53	1 15 6	
		Mining only, - -	$4 40	0 18 4	
				———	2 13 10
Vol. I.,	223	Montana.			
		Prospecting and Improvements, - - -	$4 52	0 18 10	
		Mining only, - -	$2 52	0 10 6	
				———	1 9 4
		Figure of Mining Cost, &c., used in Table III., - -			0 12 0

TABLE II.—MILLING COSTS.

References.	Page.			£ s. d.
Abraham,	13	Average, 84 South African Cos., - -		- 0 3 4
Louis,	412	Spanish Mine, Nevada County, Cal., -		- 0 1 0
,,	414	Sheba, Barberton, - - - - -		- 0 10 2
,,	414	Langlaate, - - - - - - -		- 0 3 8
Mineral Industry—				
Vol. I.,	222	Alaska Treadwell,	$0 57 cents., -	- 0 2 4½
,,	223	El Callao, - -	$1 18 ,, -	- 0 4 11
,,	223	Montana, - -	$1 85 ,, -	- 0 7 8½
		Figure of Milling Cost used in Table III.,		- 0 6 0

TABLE III.—SUMMARY OF COSTS AND GOLD PRODUCED.

Dr.			*Cr.*		
	COST PER TON.		WEIGHT AND VALUE OF GOLD.	Dwts. %	Value.
Mining, - - -	12s.		Milling, obtained	6 = 30	
Milling and Amalgamation, - -	6s.				
Pans, say, - -	8s.	£1 6 0	Pans ,,	4 = 20	£2 2 4
Cyanide, - -		0 8 0	Cyanide ,,	8 = 40	1 14 0
		£1 14 0			
Profit per ton of Ore treated, - -		2 2 4			
		£3 16 4	Gold obtained,	18 = 90	£3 16 4
			Loss of Gold in process, -	2 = 10	
				20 = 100	

The above is estimated for—
One Ton of Ore, containing, say,
One Ounce of Gold.

The references in these tables are to—

Abraham's "New Era in the Witwatersrand Gold Fields."

"The Mineral Industry." Volume I. Being the Annual Statistical Volume issued by the *Engineering and Mining Journal* of New York.

Louis' "Handbook of Gold-Milling."

III.—*The Municipal Industries of Glasgow.* By WILLIAM SMART, M.A., LL.D.

[Read before the Society, 21st November, 1894.]

OUR Municipality is a microcosm of our State. The State has its fiscal domain or private economic estate, consisting of the lands, woods, and forests of the Crown, yielding to the exchequer a revenue of £420,000—all that remains of that immense estate which William the Conqueror left his descendants for the maintenance of the kingly office. The Municipality has its Common Good; a separate estate consisting of halls, lands, buildings, feu-duties, &c., valued net at some £350,000.

The State has its industrial domain, of which the best known portions are the Post and Telegraph services, with their expenditure of over £9,000,000, and revenue of £13,000,000. The Municipality has its Markets, its Tramways, its Gas, Water, and Electric Lighting Supply.

Then, again, the State has its taxing power: its direct taxation of £17,660,000 from income tax, &c., and its indirect taxation of £45,000,000—mostly, I regret to say, from drink. Our Municipality also has its taxing power: its £427,000 for police, its £34,000 for parks and galleries, its £7,500 for city improvements, and so on.

The State, likewise, has its National Debt: its principal of £666,000,000, and its fixed annual charge of £25,000,000. Not even in this are we behind; our municipal debt is considerably over £7,000,000.

About the middle of April the Chancellor of the Exchequer presents the Imperial Budget—the accounts and estimates—and asks permission of Parliament to raise his revenue of £95,000,000 or so. About the same time the conveners of our various Municipal departments present their accounts, and the Town Council is asked to pass the assessments for the coming year.

In all these respects our imitation of the imperial housekeeping is very faithful, and it becomes clear that the work of the Municipalities and that of the Imperial Government are one—

the raising of revenue and the expending of it on certain common and national purposes being divided out between the two.

On the general question of what a State may or may not undertake, I shall not enter. I am content to follow Mill in saying that "it is hardly possible to limit the interference of government by any universal rule save the simple and vague one that it never should be admitted but when the case of expediency is strong." Aristotle's famous statement was that the State comes into existence for the sake of mere living, and continues for the sake of the good life—that is to say, while the State, historically, owes its existence to the necessity of guarding the life and property of a community against outside robbers and inside thieves, it goes on existing in order to afford the conditions of free life and development to all its citizens. If you agree with Aristotle, you will probably agree in the opinion that, as time goes on, the State will rather enlarge its expenses than curtail them—though not, it is to be hoped, in the direction of further preparation for war.

Instead, then, of laying down any general principles of the limits of a State's activity, or of that smaller part of it, the limits of municipal activity, I propose to take each of our own municipal industries, and examine its work and its justification separately.

The municipal industries of our city are the supply of gas and electric light, of water, of markets, of tramway conveyance, and of certain buildings. First let us consider the general question of gas and water supply.

Water is one of the few simple forms of wealth which society never gets beyond. It is more than a mere necessary of life; it is a necessary of all leisured and cultured life. When people have to work hard to "keep the wolf from the door," they have little time, and may be excused the inclination, for much washing; but, as leisure increases, and more of the general life is spent after hours, the necessary wash is replaced by the necessary bath. I have lived long enough to see the bath become an indispensable furnishing in the houses of the well-to-do. I hope I shall live to see the day when it is as common in poor men's homes. It is, accordingly, generally recognised as one of the first duties of a municipality, to provide in some way a steadily increasing supply of pure water, and to secure that the agency which supplies this necessary of life shall have no motive to curtail the use of it—in which you will observe that the supply of water

differs *in toto* from the supply of that with which it is often mixed!

The same applies very much to lighting. As sunshine is to the human being, so is gas or electricity to a city. It is a significant saying that every gas-burner is worth a policeman. Many things go on under the darkness that would not be possible under the gas-light; just as, in their degree, many things go on under the gas-light that would not be possible under the search-light of electricity. And, again, there are at least two new uses of gas which have a peculiar bearing on the general welfare—for heating and for power.* An open fire utilises some 3 per cent. heating power of the fuel consumed, and the best American stoves some 10 per cent. But the gas stove utilises about 80 per cent. For low powers the cheapness and convenience of gas are evident; and the economic and, I trust, beneficent revolution which would ensue if this cheap motor could be brought into people's houses, would do much to make work more productive, and labour more pleasant than it now is. The inclusion of gas supply, then, in the standard of comfort of the poorest is an object to be desired and worked for.

That the supply of these two necessaries should be in the hands of municipalities is, I think, generally admitted, except by those whose vested interests make it difficult for them to be unprejudiced. Both are, and must be, of the nature of monopolies, inasmuch as they use the public thoroughfares. It is impossible that any private company can be allowed to tear up the streets, block traffic, and destroy property and income at will. If there is to be competition in their supply, it must be strictly limited, and the powers of the competing companies regulated. I imagine most economists will agree that the alternative plan, of dictating price of supply and limiting dividends, has not been found so economical or so profitable to the community as where municipalities have taken the work themselves.† At any rate, the trend of progress is evidently in this direction, and cities that delay too long find themselves burdened with heavy compensations. We ourselves, although we took over the gas supply some five-and-twenty years ago, have on our books £415,000 of gas annuities, on which we must pay 9 per

* In Northampton over 40 per cent. of the gas is used for other than lighting purposes.

† It must be admitted, however, that the sliding scale, which allows an increase of dividend with each reduction of price, seems to have worked well in regard to private companies.

cent. and $6\frac{3}{4}$ per cent. in perpetuity, unless we buy them up at the market price.

The mention of monopoly, however, reminds us that, in examining the direct management of gas and water supply in our city, the ordinary criteria of economic judgment are wanting. A municipal monopoly can "make" its price, and can make it sufficient to cover any cost; whether it be the cost under mismanagement and corruption, or the cost of honest and economical working. It is even more powerful than a private monopoly, inasmuch as it is not actuated by the motive of getting the largest profit from the smallest capital. It has virtually taxing power in its hand, inasmuch as streets, at least, must be lit whatever gas costs. The history of gas monopoly in American cities under private companies should be read by all who take pride in our municipal management.

It may be thought that, in the case of gas at any rate, it is not difficult to find out what the cost of production is, and that this cost gives us a criterion of economic price. It is, indeed, easy to find what the cost to each gas corporation is, but I am afraid this gives us little indication of what the cost should be. We want the test of competition, on which all our notions of "just price" have, under modern conditions, been based. Perhaps I may remind you how often it has happened in economic history that certain of our industries were said to be on the brink of ruin, by reason of the low cost of production in foreign countries, till such time as their undertakers found that there were means of reducing cost at home.

Again, it may be pointed out that, in gas and water supply, cost varies from place to place, according to geographical and physical conditions. Not to speak of the obvious case of the water supply, where cost must vary according to the distance and the nature of the source, take the case of gas. Gas coal is a bulky article whose carriage must be expensive. Consider, then, the difference between the cost of gas manufactured, as it were, at the pit-head, and of gas whose raw material comes from another county. The amount got for residual products, again, in our case, comes to nearly a fourth part of the price of the gas produced in joint supply with it. But coke, also, which is one of the residual products, is a bulky article, and the profit on its sale will depend on whether there is a market at hand for it or not. It seems to follow that, however accurately the cost of gas may be

determined in one locality, it gives little criterion for the cost in another.

Almost our only standard of comparison, then, in judging of the success of these industrial undertakings, is to be got by comparing the quality and price of gas and water supplied by agencies in other cities, with the reservation that those agencies, whether public or private, are also monopolies.

Taking this standard, while the Americans somewhat sadly confess that "British cities have the cheapest gas in the world," we do not quite realise how well-off we in Glasgow are in comparison even with other British cities. Our gas is at present of 21·3 candle-power—the statutory minimum being 20 candles—and is supplied into our houses at 2s. 6d. per 1,000 cubic feet. Now the candle-power in other British cities is as follows.* The three great London companies are under 16·50; the suburban companies, 14·50 to 17·00. Of provincial corporations, Leicester shows 16·65; Birmingham, 17·28; Bolton, 17·99; Salford, 18·54; Nottingham, 19·00; Leeds, 19·00; Manchester, 19·11; Carlisle, 19·16; Oldham, 19·30. Of provincial private companies, Plymouth shows 14·50; Brighton, 14·57; Portsea, 14·82; Bath, 16·00; Newcastle, 16·00; Derby, 16·50; Bristol, 16·56; Sheffield, 17·88; Preston, 18·75. Dublin is 16·50. Liverpool alone is on the same line, viz., 21·59.

As to price: the London companies, on average of the three, charge 2s. 10d., and the suburban companies, 3s. 1d. Leeds charges 2s. 2d.; Manchester, 2s. 6d.; Liverpool, 3s.; Dublin, 3s. 7d. The average of the provincial corporations is 2s. 5d., but their candle-power is 14·5 to 17·0. Of the provincial private companies only three are lower—namely, Newcastle, with 1s. 8d.; Plymouth, 1s. 9d.; Portsea, 2s. 4d.—but their illuminating power is only 16·00, 14·50, and 14·82 respectively. It should be noted that in Glasgow meters are supplied free, which is equal to a reduction of about 3d. per 1,000 feet. In all the other towns mentioned, with the exception of Birmingham, a meter rent is charged.

Another test of economic working is the proportion of capital employed to gas produced. Evidently the most economic company, *ceteris paribus*, is that which works with the smallest

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* I take the figures from Field's "Analysis of the Accounts of the Principal Gas Undertakings in England, Scotland, and Ireland for 1893."

capital. In this respect, Glasgow comes easily first; her capitalisation, in fact, being 6s. per 1,000 feet, or about half that of similar concerns with which I have already compared results. The average of the English provincial corporations is 11s. 8d.; of the private companies, 11s. 2d. Dublin is 17s. 1d. The average for London is 12s. 4d.; for the suburban companies, 12s. 11d.

It is when we turn to the United States that we find most reason to congratulate ourselves.* Only nine cities own their gas supply, five of these, however, showing the honourable record of having paid for their works out of earnings. All of them have had the same experience in the past: of competition, more or less regulated, in the supply; of competition in every case ending in combination; of combination ending in high prices—prices often shamelessly high; the evident tendency everywhere being towards municipal supply.

In regard to illuminating power, the only figures I can find are that Philadelphia has a candle-power of 19·35, and that the average of Massachusetts is 17·79. For New York, Baltimore, and some other cities, 21 to 25 candle-power is claimed.

In regard to price the most significant thing I know is that it varies by leaps of 25 cents—that is to say, gas is either 4s., or 5s., or 6s. per 1,000 feet; it scorns anything less that a shilling rise or a shilling fall. You will remember how discontented we were when our price, owing to a coal famine, rose threepence!

In New York State a law of 1886 reduced the price of gas to $1.25 in cities of over a million inhabitants. 10 Massachusetts cities average $1.40, Boston being $1.23 and Fall River $1.57. Philadelphia charges $1.50. The average price in 290 cities in 1887 was $2.00.

But the evils of private competition are best seen in the immense over-capitalisation of the American companies. While our capital employed per 1,000 feet is, as I said, 6s., New York City shows $6.48; Jersey City and Chicago are over $13.50; St. Louis is $19.50; and New Orleans $20.25. The average capitalisation in the fifteen largest cities of the United States is $9.85. Against this Philadelphia, which itself shows traces of buying out its old private companies, is under $3.

* The facts as to American gas supply are taken mostly from the admirable monographs of the American Economic Association, and principally those of Professor James and Professor Bemis.

It is of interest to note that, in many quarters, gas is considered a commodity on which indirect taxation may well be levied for local purposes. Philadelphia, for instance, sells gas through her municipality at $1.50, but 50 cents of this go direct to the city treasury, the sum per year amounting to over a million dollars. Liverpool, Manchester, and other municipalities act in the same way, to such an extent that Mr. Livesey uses it as an argument against municipal supply. We, on the contrary, aim only at keeping down the price.

I come now to the financial position of our own Gas Trust as at 31st May. Under the Glasgow Corporation Gas Act of 1869 the Corporation, after determined opposition, bought up the two existing private companies; the price being an obligation to pay, in perpetuity, the sum of £34,762 10s.—that is to say, perpetual annuities to the amount of £300,000 at 9 per cent., and £115,000 at 6¾ per cent. The Corporation simply stepped into the place of the old companies, taking over also their mortgage debt of £119,265. In succeeding years a very great expenditure of capital was found necessary, and further money was raised on mortgage at various rates, principally 4 per cent., the amount borrowed rising to £650,000 in 1874-75. From that year the mortgages were speedily repaid out of profits, and after 1886-87 any new capital required was got from the Corporation Loans Fund at 3½ per cent. In 1889-90 the sum thus borrowed was reduced to £48,000; but two years after it rose to £480,000 and is now £550,000. This increase was occasioned by the buying up of the Partick, Hillhead, and Maryhill Gas Company, and the Pollokshaws Gas Light Company, and by extensions, just completed, at Tradeston and Dawsholm. Provision for clearing off this debt is met by the statutory enactment that not less than 1 per cent. on the money borrowed shall be set apart annually, together with interest accruing on previous similar sums, as a Sinking Fund. For the last few years the policy has been to keep down and reduce the price of gas rather than exceed this minimum. It will be understood that the £415,000 of annuities could only be bought up in the open market, and at the market price—which is, to-day, £303 and £236 for the 9 and 6¾ per cent. respectively. It is, perhaps, not generally known that the Town Council has power, in event of the Trust being unable to pay the annuities, to impose a special tax of 6d. per £ on the rental of the city. The Sinking Fund now amounts to £282,028.

Examining the capital assets, we find them to consist of works, gas-holders, pipes, meters, &c., to the value of £1,359,095. This plant is entered at first cost, less an annual depreciation on the gradually depreciating capital, additions during the year being added on after depreciation is reckoned. The depreciation taken off this year is 3½ per cent. on works and pipes and 6 per cent. on meters; but it has been as low as 1 per cent., and as high as 10 per cent. The liabilities are £1,191,535, leaving a balance of assets of £167,560.

Looking to revenue account we find the following items of expenditure: — Manufacture, £382,089 16s. 5d.; distribution, £44,372 13s. 5d.; rents and feu-duties, £6,948 0s. 1d.; rates, assessments (imperial and local), and taxes, £13,162 16s. 4d.; management, £8,986 7s. 5d.; law and parliamentary charges, £281 18s. 8d.; depreciation on works and pipes, £33,270 0s. 11d.; depreciation on meters, £9,034 15s. 6d. The total expenditure is thus £498,233 13s. 7d.

Against this the sale of gas brings in £463,457 12s. 1d. Of residual products, coke fetches £38,514 12s., and tar and ammoniacal liquor realise £65,084 1s. 11d. Miscellaneous revenue amounts to £2,490 8s. 6d. The total is £569,546 14s. 6d., leaving a balance to credit of profit and loss of £71,313 0s. 11d. Of this balance, £33,748 11s. 10d. went to pay the annuities, £27,868 16s. 2d. to pay interest to Loans Fund, and the 1 per cent. sinking fund absorbed £5,550, leaving a net surplus of £4,145 12s. 11d.; out of which the electric lighting deficit was met, and a sum of £3,500 transferred to the Insurance and Contingent Fund.

The present and future of the Gas Trust may be summed up thus:—Assuming the continuance of present prices for coal and labour, the Gas Committee seem to be able, by charging 2s. 6d. per 1,000 feet, to manufacture and distribute gas of 21·3 candle-power; to write down their works and pipes at 3½ per cent., and their meters at 6 per cent.; to pay interest on the annuities and borrowings; and to lay aside for the Sinking Fund the amount which Parliament has declared sufficient. If the cost of manufacture should rise—say, from rise in price of coal or labour, or from decrease in value of residual products—an increase of price of gas would naturally follow. Otherwise, in normal circumstances, nothing but possibly a great fall in the consumption of gas would necessitate such a rise.

The only point on which there may be question is whether the rate of depreciation calculated is enough to keep pace with improvement in processes. Holding, as most economists would hold, that the financial position of a municipal concern should be judged by commercial principles, it follows that no manufacturing business can be accounted in a healthy state unless it can write down its property, or accumulate a reserve sufficient to enable it to throw out either plant or process as it becomes antiquated, and replace it by the most economic substitutes.

Whether the amount of depreciation written off would be counted enough for this purpose or not, I have no means of knowing; but that the Gas Committee are alive to this necessity is proved by the fact that lately the Dalmarnock and Tradeston plant was reconstructed on the new and improved system known as "Siemens' Regenerative Process," and that the expense of this was ultimately met out of revenue.

Electric Lighting was added to the sphere of the Gas Committee in 1892, when it purchased the business and plant of a private company. The work is as yet little more than tentative, the private consumers numbering only 378 persons, and only one district of the city being supplied. The gross revenue last year was £18,015, and the expenditure, counting depreciation, £13,985, showing a balance of £4,031; from which, however, fall to be deducted interest and sinking fund, £4,638, showing a deficiency of £607, met from the surplus on the Gas accounts. The Trustees, however, are confident of better results with the extension already demanded. Meanwhile, the original price of 7d. per Board of Trade Unit has been reduced to 6d. The capital expenditure of this department is £116,585.

Turning now to the no less important matter of our water supply, the present position, as every one knows, is that the Water Commissioners supply Loch Katrine water at 6d. per £ of rental for domestic purposes, at 1d. for public purposes, and 4d. per 1,000 gallons for trade and other purposes.*

Down to the beginning of the century, the only public water supply of the city came from thirty pump wells. It was counted an enterprising act when, in 1804, a man started selling pure spring water from a cart at a halfpenny per stoup, and made a fortune out of it.

* The 1d. per £ of "public water rate" is merely the owner's assessment.

In 1806, the Glasgow Water Company was formed, drawing its supply from the Clyde at Dalmarnock, two miles above Glasgow Bridge. Two years later came a rival concern, the Cranstonhill Water Company, pumping from the river at Anderston till 1819, and after that at Dalmarnock, with the usual result that, after many years of unprofitable working, the two companies amalgamated in 1838, the supply price and dividend being thereafter regulated by Parliament. In 1846, the Gorbals Gravitation Water Company obtained an Act for supplying water from the Brock Burn to Gorbals and other districts on the south side of the river. In 1855, after bitter opposition, the Loch Katrine scheme was adopted, and the Corporation absorbed the other two undertakings, paying the shareholders of the Gorbals Company 6 per cent. perpetual annuities on their capital of £180,000, and the Glasgow Waterworks Company 6 per cent. annuities on £41,680, and 4½ per cent. on £303,700—in all, a perpetual burden of £26,667 6s., or a capital debt of £525,380. The new capital required for the Loch Katrine works was got on mortgage till 1884, since when the Loans Fund has provided the necessary capital.

A well-known writer on water-works (Silverthorne) has said that "reductions in water rates by companies are practically unknown." But our Water Trust accounts show reductions from 14d. in 1855, to 1s. in 1865, to 8d. in 1871, to 7d. in 1887, and to its present rate, 6d., in 1890.

For these reductions the Water Committee are really entitled to more credit than the Gas Committee for the similar reductions made by them. As is well known, while the elasticity of demand for gas and water is perhaps equally great—the appetite here growing by what it feeds on—the elasticity of revenue is very different. Increase of demand for gas means increase of consumption and increase of payment. But increased demand for water, where the payment is not measured by a meter but by a rate of so much per £ of rental, does not mean increase of payment, inasmuch as the consumers pay the same amount whether they use little or much. Apart from the natural increase of population and houses, the only way to increase the revenue from water is to raise the rate.

What the Corporation paid to the various proprietors for the right to draw away three feet from the ordinary summer level, and for leave to catch, store, and draw away four feet above that

level, is an interesting question upon which the Water Committee, very properly, are not caring to give much information. To those who are simple enough to believe that Loch Katrine was no man's private property, and that we had only to pay compensation for disturbance, I may state that when, in 1885, the committee arranged for an extension by catching an additional supply from heaven which would store other five feet above the previous level, one of the schedules bears that it is an agreement between His Grace Douglas Beresford Malise Ronald, Duke of Montrose, as the first party, and the Magistrates and Council of the City of Glasgow, as the other, whereby the first party, as "having proprietary rights in Loch Katrine and Loch Arklet," consents not to oppose the Bill in consideration of a sum of £10,000 for Loch Katrine and £3,000 for Loch Arklet; and it is expressly stated that these sums are simply "compensation for the right and privilege of storing in and taking from them an additional supply of water, and for the right of access at all times to the said lochs." This has nothing to do with payment for damage done to property, such as submerging the Stronachlachar Hotel, damaging a farmhouse and steading, submergence of adjoining lands and timber, and wayleaves for aqueducts, pipes, &c.: these various claims were all paid for separately. It appears that other landowners also claim proprietary rights over the Loch, the Baroness Willoughby de Eresby getting £10,000, and so on. It is not, perhaps, known that the Water Commissioners were obliged to buy up the feuing rights round Loch Katrine and Loch Arklet. It is only just, however, to say that these sums are utterly insignificant in comparison with what has been paid by Manchester for similar rights.

In the case of water, as in the case of gas, there is no competitive comparison: the standard must be the price paid by other cities for their supply. In this respect we have not, perhaps, so much reason to compliment our Committee as to thank Nature, which provided a 3,000-acre area of the purest water in a district where the rainfall is 80 inches, and placed it in such a position (360 feet above the tide at Glasgow) that it could be tapped and led into the city by gravitation.

Taking this standard, however, I find, as in the case of gas, that we do not quite realise how well off we are. Only two cities charge less. Dublin provides for domestic supply at 4½d., but her "public rate" is 3d., her trade rate 6d., and the water is not so good.

Edinburgh charges 5½d. for domestic purposes, but shows 6d. for trade purposes. Aberdeen and Perth charge, for domestic purposes, 7d.; Paisley charges 8d.; Greenock, 9d.; Dundee, 1s.; and their other charges are higher than ours. Liverpool and Manchester charge 7d.; Belfast, 10d.; Birmingham and Leeds, 1s.; and many of these towns charge extra for baths and conveniences, whereas our domestic rate allows of unlimited consumption within the house.

The revenue last year was £177,950 18s. 3d. (being £58,000 from domestic, £16,000 from public rate, and £98,000 from manufacturing and trade uses), and the expenditure was £135,061 14s. 8d.; leaving a balance of £42,889 3s. 7d., of which £39,611 16s. 8d. was carried to Sinking Fund.

When we turn to the Stock Account we find that the whole amount expended on water-works by the Commission since 1855 (this including, I suppose, the annuity capital which would be accepted as the value of the works taken over from the old companies) appears as assets. This means that no depreciation account has been opened, and that the works stand at the same value as they might be assumed to be on the day when they were erected. The depreciation, however, is to be found in another account, namely, in the Sinking Fund. That fund is, under statute, 1½ per cent., and is applicable equally to the borrowings from the Loans Fund and the annuities at an estimated value of £720,000. Now, this 1½ per cent. is not, as in the case of the Gas Trust, a definite percentage on a gradually decreasing capital, but is 1½ per cent. laid aside on all the money borrowed. Thus the calculation is that in 66⅔ years, if no additions were made, and if the plant could last that time, the debt would be cleared off, and the unencumbered estate of the Water Commission would consist of the water-works and plant as they then existed. In other words, the assumption is that the Sinking Fund is not merely a repayment of debt, but includes depreciation; or, to put it another way, that the debt will be wiped out long before the concrete capital in which that debt was embodied will be worn out.

The Water Committee, then, seem justified when they say that the new extension, by which the present 37,000,000 gallons of daily supply can be increased to 70,000,000, will not add a farthing to the rates; while the new hydraulic power supply works now being erected are expected in time to show a profit.

The borrowing powers of this Trust were £3,250,000, of which £644,322 is unexhausted. The total amount expended on the water-works to date is £3,174,672, which now appears as capital assets. The Sinking Fund is £730,582.

The third of our municipal industries is carried on by the Markets Trust. The supplying of public markets for certain goods has often been a function of municipalities, and the present Trust dates back practically to 1820, although not formally constituted till about 1850. It supplies buildings for markets and slaughter-houses; the rates and dues of which are paid by the traders in live home cattle and horses, in butcher meat, and in fish. The revenue this year is £22,100, and the expenditure (including interest, statutory Sinking Fund, and some extraordinary expenditure) is £18,369, leaving a surplus of £3,731. The assets are £259,836, and the liabilities £162,206, leaving a surplus of £97,630. As these assets consist of markets, slaughter-houses, lands, and houses, and are all realisable, it may be assumed that there is no question as to the financial soundness of this Trust.

These three industries, then, are the notable ones carried on by independent trusts formed for the purpose. But, besides these, there are two undertakings managed, I might almost say by accident, by other departments. These are the running of the tramways by the Corporation, and the building and management of house property by the City Improvement Trust.

As you all know, twenty-three years ago the Corporation laid down the permanent way, and leased it to the Glasgow Tramway and Omnibus Company, in consideration of certain rents and mileage rates. Five years ago, negotiations were entered on for renewal, but, these breaking down, the Corporation entered on possession of their own lines on the expiry of the lease on 30th June last, and are now working the traffic through a Tramways Committee. As a temporary arrangement, this committee takes over the lines at the price of their construction (including Parliamentary expenses), less sinking fund; maintains them; and undertakes, in addition, to pay to the Corporation the annual rent of £9,000. The capital required is borrowed at the usual rate; this amounted, up to the end of September, to £330,000. It is, of course, yet too soon to say much about the success of this new departure, beyond stating the fact that, along with the introduction of halfpenny stages, the fares have been very much reduced—on some routes by one-third—and that the

position of the employés, as regards hours of labour, has been much improved. As the old Company during the last ten years paid dividends averaging 7½ per cent., and wrote off most of the value of their cars before the conclusion of the lease, it should not be difficult for the Corporation at least to make ends meet.

From the house-building operations of the Improvement Trust I should separate off the building and maintenance of the Model Lodging-houses. These were erected from other than economic considerations. Even economically, however, it seems correct to say that there is a class of society which should, perhaps, not be left to the action of unlimited competition—the class on the margin of starvation. It would, I think, be hard to prove that the demand of persons irregularly employed, plus the smaller demand of tramps and people who have no money except what they get from charity, would naturally draw forth a supply of healthy and clean lodgings, and experience has shown that to leave this supply to private enterprise is often to encourage the propagation of disease and vice.*

But, apart from these, the City Improvement Trust has, of late years, entered on the supply of houses for working persons in the lower parts of the city. It has built several tenements, and it has others still in process, the total cost being estimated at something under £100,000.

The financial results of this experiment for last year are as follow:—No. 1. block consisting of 5 houses of three apartments each, 31 of two apartments, 12 single-apartment houses, and 11 shops, cost £10,294, and yields £3 18s. 10d. per cent. No. 2, consisting of 3 houses of three apartments each, 27 of two apartments, 12 single-apartment houses, and 14 shops, cost £12,143, and yields £3 11s. 7d. per cent. No. 3, consisting of 36 single-apartment houses, cost £3,326, and yields £2 17s. 4d. per cent. Unlike many similar municipal experiments, these returns are brought out after calculation of full feu-duties, respectively £225, £244 1s., and £55 17s. Indeed, to be just to the Trust, it should be mentioned that these feus are calculated on an old

* The function of a municipality, however, to show the lead in such a matter and establish a "model," is witnessed in the fact that Mr. Robert Burns, after gaining his experience as superintendent for eight years in the first Corporation Lodging-house, began the erection and running of those well equipped and admirably conducted private lodgings which now rival those of the Corporation.

valuation which is much above what could now be realised, and it is fair to assume that the returns actually realised are higher than those shown.

Assuming that these returns are kept up in the future, and that all proper charges have been included in the annual expenditure, it appears as if this experiment had justified itself by success—if success is to be measured by the avoidance of present loss to the ratepayers. When a Corporation borrows at less than 3 per cent. from the public, and invests that money in property which yields at least that amount, neither is the ratepayer directly taxed, nor is the Common Good Estate of the Corporation, in which every citizen is a part owner, in any way prejudiced.

Questions, however, emerge as to future gain and loss. The Improvement Trust is a temporary one, and looks forward, some time or other, to realise its assets and wind up. It may be argued that, if private enterprise was not able to take up the feus and build, the property built on this ground by a Corporation is not likely to realise what was spent on it when it comes to be sold.

But, apart from this, it is a commonplace to say that a municipality cannot afford to be guided solely by financial principles in its administration of the citizens' money. There may be considerations strong enough to outweigh any financial success.

The view generally taken of undertakings like this—and I think it is the view which appeals to most of us—is that there must be very sufficient reason shown for a municipality doing anything that can be done as well and as cheaply by private persons. There is ample argument for taking over a monopoly of some necessary supply in its early days, if it can be done, for this is to secure the future possession of an increment which, as unearned, may as well go to the common good as to individuals. There is reason, whether sufficient or not I shall not say, in the demand that the municipality shall take over the liquor traffic, just for the exactly opposite reason—namely, that the consumption of liquor is a consumption which we wish to limit. But why, of all industries, select the innocent trade of house supply for invasion, and so compete with an industry which is neither a monopoly nor an evil?

The reasons given by the Trust are these:—Owing to the stagnation in trade, the City Improvement Trust found itself in possession of large areas, which it had cleared of slums, but could neither feu nor sell. Past experience seemed to show that,

on the whole and in the long run, land in the centre of the city did increase in value, and was accordingly a safe investment to hold. But meantime these building sites were earning no return. At the same time came the revelations of the housing of the poor in London, and the agitation for supplying the very poor with houses that should not outrage the new canons of sanitation and cleanliness. It seemed to the Trust that it would be leading the way in this direction, and at the same time improving the financial position of the Trust, if they utilised their unfeued spaces by erecting dwellings that would serve as models of what dwellings for the poor should be. Guided by these motives, and seconded, possibly, by those who saw in this the beginnings of a socialistic system which would extend in time to other private enterprises, the Trust began to erect the model dwellings in Saltmarket and elsewhere.*

I am not sure that I shall earn the gratitude of the Improvement Trust Committee when I contend that the enterprise, in this respect, has justified itself by its failure. The sinking of £100,000 in buildings will do very little, one way or another, to affect the supply of houses; it may be quite sufficient to decide an economic question of the deepest practical importance. Five years ago, the Workmen's Dwellings Company was founded for the purpose of providing comfortable and thoroughly sanitary houses for working people, at the rents current for the same amount of accommodation in the neighbourhood. In the new building in Rottenrow it provides two-roomed houses at 9s. 8d. per month, with a bonus of two weeks free in the year, while the Improvement Trust charges 11s. 4d. and 13s. 4d. for its one-roomed houses of substantially the same dimensions. In its last annual report it is said that the rents current in the Company's houses are practically the same as those of the "ticketed houses"; but, keeping rents at this low figure, the Company

* It will not, I trust, be thought that I am depreciating in any way the magnificent work done by the Improvement Trust in the past. Its primary object was to clear the city of some very foul properties and let in light and air to some excessively congested districts. It has done this effectually, and withal the assessment is now only ½d. per £, instead of the permissible maximum of 2d. I have no sympathy with those who look on the money thus spent by the Corporation as purely a commercial investment. The question, however, now raised is quite apart from this—namely, if, in its haste to get quit even of this last ½d., it is not doing harm in entering on a new industry that was not originally contemplated by the promoters of the Trust?

cannot obtain more than 3·7 per cent. of return—and that at a time when repairs are at a minimum and there are no unlet houses. And here we have the Municipality, with all its experience in municipal industries, and obtaining its money at the cheapest rate, making a similar experiment, charging considerably higher rents, and able to do no more than clear interest on the money borrowed,—the inference being that, if the Trust had really faced the housing of the very poor, as the private company has done, it could not pay its way at all.* I contend that the City Improvement Trust, in its building scheme, has made an experiment which had to be made, and that it deserves our gratitude as citizens for the lesson it has demonstrated.

What is that lesson?

From this place last year I had occasion to point out, what nobody seems to take to heart, that, with all our wealth, we are still very poor. The money income of our nation, divided out equally among the population, would give, roughly, £33 of income per head, which, I am afraid, is not a "living wage" for anybody. And even when we put this statistic in the more truthful way—for nothing lies like figures except facts!—that an equal division of income would give only £165 per family of five, it shows how impossible it is just now for even a large minority of us to have, in our own houses, anything approaching luxury. Even if we were to discover any plan by which all the new wealth that comes into the world hereafter should go solely to the classes who have not enough now, there are a great many necessaries of thoroughly wholesome life which, for many a long year yet, we could not expect to see in poor men's homes.

Now, in this matter of housing, our appetite seems to me to have outrun our pockets. It is not so long since water led into private houses was unthought of, not to speak of baths, wash-hand basins, and all manner of conveniences. The standard of comfort among the rich has risen so rapidly that many of us are making similar demands for the poor, without asking the previous question of whether the national income can afford it.

I make the suggestion with diffidence—for it is always an

* In fact, in its latest official publication, the Trust confesses that the buildings, with the exception of Block No. 3 (which contains 36 houses only), "have not provided houses for the lower working classes."—"Notes on the Operations of the Improvement Trustees," by Wm. C. Menzies, Manager, 1894.)

ungrateful thing to throw cold water on enthusiasms that one sympathises with,—but should 20s. a week pay a rent of more than 3s. a week? and will 3s. a week pay for all the conveniences which we are demanding that builders should supply?

The experiment we have just been considering seems to answer in the negative. I desire, then, to point out that, if this conclusion is correct, any further building on the same lines by the Municipality is subsidising low wages by paying part of rent—in other words, redistributing wealth by taxation. This may be right and admirable, or it may not—I merely point out the fact.

In conclusion, let me say that this—success or failure, as you like to consider it—points the moral which I have tried on several occasions to bring out, that he is still the benefactor of his race who makes two blades of grass grow where one grew before.

If we are still so miserably poor that we cannot afford every man a decent home, it is time we were considering if the better distribution of wealth is the *only* question of any importance. The manner of our *consumption*—the wanton, selfish, and harmful eating and drinking and wearing out of wealth, calling forth a demand which binds up capital, and muscular force, and brains with the supplying of unthrifty luxuries, till vested interests and the interests of the working classes themselves, as producers, nearly strangle reform, and warehouses are filled to bursting with goods for which no man is any the better in body or mind—this surely is worthy of some consideration. But perhaps the most pernicious heresy in popular economics of the present day is the idea that there is wealth enough and to spare somewhere, and that it can be got by simple insistence on a higher wage. In face of the figures of national income which I have presented, it ought to be evident that our working classes, as well as our idle classes, must do their share in growing the second blade.

If an eight hours' day will give us as much as one of ten hours; if 40s. a week will give us twice as much as 20s. did; if trade-union restrictions will make every workman a better workman—let us have the shorter day, and the higher wage, and the trade union. But, in view of the present waste in consumption, and of the impossibility of anything like an equal distribution of income, it seems to me folly to think that there is any way of securing every man a decent house but by a very great increase in the wealth production of the community.

IV.—*On the First Edition of the Chemical Writings of Democritus and Synesius.* By Professor FERGUSON.

POSTSCRIPT TO PART IV.

1. When I saw M. Dujardin, the distinguished photo-artist, in Paris last month, he undertook to send me a negative of the unique copy of Democritus by Pizimenti, in the Bibliothèque Ste. Geneviève. Having now received it, I am able to give a reproduction of it as the most important addition that I can make to what has been already said.

2. There are two points specially to be noticed. The first is the date: MDLXXII. This is the only copy of the book I have met with having this date, although others possibly exist without having attracted attention. All other copies which I have seen have had the date altered to MDLXXIII., by the subsequent insertion of an additional figure I.

The second point is the initial A of ABDERITA. In all copies except this one, the correction of the original misprint, IBDERITA, has been effected by means of a printed A. In this copy, however, the alteration has been done with the pen. To print the correction, therefore, was probably an after-thought, and may have been carried out at the same time as the alteration of the date. If another copy dated MDLXXII. be found, in all probability the original misprint IBDERITA will either have been left unaltered, or corrected by hand as in the present copy. If this inference be correct, then it may be concluded that the date which has been torn away from the copy in the Mazarine Library (see Part IV., § 3, and the facsimile) had been changed to MDLXXIII. like the others, because the initial I has been *reprinted* A, and not altered by hand. This is an entirely new aspect of the subject, which did not occur to me till I re-examined the Ste. Geneviève copy. It can be dealt with only by comparison of copies dated MDLXXII., and if in any of these there is a *printed* correction of I to A, the argument necessarily falls to the ground. I believe, however, that, when the date has

DEMOCRITVS ABDERITA DE ARTE MAGNA,

Stae Genovefae 1733.

Siue de rebus naturalibus.

Nec non Synesii, & Pelagii, & Stephani Alexandrini, & Michaelis Pselli in eundem commentaria.

Dominico Pizimentio Vibonensi Interprete.

PATAVII
Apud Simonem Galignanum
M D LXXII.

not been changed, the correction of I to A will be in manuscript, if made at all.

3. It is with much satisfaction that I am able to present this facsimile to the Society, for, as I have repeatedly said, it confirms all the theories and arguments which I had put forward as to the original date of the book, before I had seen it. See particularly Part I., 1884, § 10; Part II., 1890, § 12, and postscript; Part III., 1891, §§ 7, 8.

4. Reuvens,[1] speaking of the Greek alchemical MSS., mentions the fact that a small part of the original texts had been printed by Fabricius, Ducange, d'Orville, and Bernard, and in Latin by Pizimentius. He adds:—

„ Mais toujours est-il vrai de dire que la plupart des traités en question sont restés inédits, d'autant plus que même la traduction de Pizimentius [1573] est presque introuvable, et que d'ailleurs, pour l'étude approfondie de cette matière, il est indispensable de posséder les textes grecs originaux, que cet éditeur n' a pas joints à sa traduction."

Reuvens is quite correct about the necessity of basing the study of the subject upon the original texts, and this can now be done in an edition, the appearance of which would have gratified not only Reuvens, but Beckmann, Borrichius, Leo Allatius, and others who were deeply interested in the early history of the science.

Sixty years ago Pizimenti's little volume was "almost not to be got." Those who have followed the inquiry will, I think, admit that this account of Pizimenti's book is still strictly true.

5. As a proof that no subject ever really comes to an end, a reference which is new may be given.

In the *Catalogue des Manuscrits Grecs des Bibliothèques de Suisse*, Leipzig, Otto Harrassowitz, 1886, 8°, Henri Omont quotes a MS. in the Bibliothèque de la Ville, at Berne. It is No. 113 in his list, and apparently No. 579 of the Berne list, and it is of the XV.-XVI. century, written on paper. Of this MS. folios 41-47, in the hand of Ange Vergèce, contain the following:—

"Synesii philosophi liber ad Dioscurum de libro Democriti. Τῆς πεμφθείσης μοι ἐπιστολῆς . . . "

It is evidently an unknown copy of the Commentary of Synesius upon Democritus addressed to Dioscurus. Comparison with

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[1] *Lettres à M. Letronne . . . Sur les Papyrus Bilingues et Grecs, . . . du Musée d'antiquités de l'Université de Leide*, Leide, 1830, 4to. Troisième Lettre, p. 71.

other MSS. alone would show which of those earlier than itself it most resembled.

The text of this Epistle, as it exists in the St. Mark MS., will be found in Berthelot's edition, Paris, 1888, volume containing the Greek text, p. 57. Pizimenti's version begins on f. 11 *verso*:—

> "Epistolam tuam ad me missam de diuini Democriti libello non negligenter accepi, . . . "

The Berne MS. was not known to Dr. Kopp when he drew up his account of the Greek Alchemical MSS. (see *Beiträge zur Geschichte der Chemie*, Braunschweig, 1869; and my Address to the Chemical Section of the Philosophical Society, *Proceedings*, 1876-77, vol. X., pp. 373-74), and the above is the only notice of it which I have observed.

GLASGOW, *25th October, 1894.*

Erratum in Part II., § 10, line 15, *for* Birckmann *read* Beckmann.

V.—*The Labour Colony System, and its Adaptation to our Social Needs.* By Professor R. PATRICK WRIGHT, F.H.A.S. *(A Communication from the Sanitary and Social Economy Section.)*

[Read before the Society, 9th January, 1895.]

IN a lecture, intended to be of a somewhat popular character, which I have delivered several times this winter in Glasgow, and which will be twice re-delivered in the current month, I have endeavoured to give a brief account of the history of the origin and extension of the labour colony system, of the nature of a farm colony, of its methods of management and control, of the character of the men with whom it deals, of the physical and moral change produced in them by their residence on the colonies, of the amount of success attained, and of the reasons why such colonies should be under the control of Christian and philanthropic associations rather than of Town Councils, Parochial Boards, or other bodies representing ratepayers. I have also, in the same lecture, illustrated the general methods of management and control, and the means adopted for keeping the men employed in wholesome and regular labour, by giving a description in some detail of two farm colonies recently visited by me in South Germany—the one in Baden, the other in Wurtemburg.

In to-night's paper I propose to treat the subject from an entirely different standpoint. I propose to speak of the need that exists for such a system, of the manner in which the system meets the requirements, of the cost of the system and the conditions affecting the cost, and of its efficiency and economy as compared with other methods that have been adopted to deal with aspects of the same problem.

On the 20th January, 1893, the Labour Centres Committee of the Glasgow Association for Improving the Condition of the People made certain recommendations, which were subsequently approved of and adopted by the Council of the Association at a meeting held in April of the same year.

The recommendations were as follow :—

"1st. That sufficient centres be established, in co-operation with the Charity Organisation Society, where employment, at subsistence wages, would be provided at once to those unemployed who should apply—said centres to serve as a means of sifting out those who might be fit for a farm colony.

"2nd. That thereafter a farm colony be established, subject to suitable provisions as to admission, superintendence, &c., &c."

The first part of these recommendations has been so far carried into effect by the Charity Organisation Society. A labour yard has been opened in the north-east section of the city, and, as soon as its success is proved, it is probable that more, if required, will be opened in other districts. The second part of the recommendation still remains a dead letter, but the Association hopes to take active steps to carry it into effect in the coming spring, if the public of Glasgow and the West of Scotland will give the requisite financial support.

The argument for the necessity amongst us of such agencies as are provided by labour yards in the cities and farm colonies in the country is dependent entirely on the existence, as a constant, difficult, and even dangerous factor in our social system, of a body of men, of whom one section may be correctly spoken of as "the unemployed," and of whom another section is more correctly described under the popular designation of the "submerged tenth." All the members of this body, good and bad, are men not engaged in any regular occupation, men either unable to find work or undesirous of working. Statistics with regard to the number of the unemployed are somewhat unsatisfactory, for the number fluctuates from year to year according to the conditions of trade and other circumstances. But at no time, not even in the periods of greatest commercial prosperity, can they be said to be non-existent. There is always a class of the unemployed, able-bodied men, who will not work, or who cannot find work.

The unemployed have been classed in a Report of the Dundee Charity Organisation Society in the following manner :—

"(1) Those who are unemployed during the winter months owing to the nature of their work, such, for example, as painters, masons, masons' labourers, gardeners, and all outdoor labourers generally, in which cases the shortening of the day, the state of the weather, and such like causes, necessitate a cessation of work, more or less, recurring regularly every year; but such want of

work, such unemployment, is an ordinary trade risk, and is so regarded by those engaged in these trades, and is generally discounted in the wages regularly earned when in full time."

It is true, as stated, that the wages earned by masons, gardeners, and similar skilled labourers, are sufficiently good to enable them, if provident men, to live comfortably enough through some weeks of idleness, but that is not equally true of masons' labourers and outdoor labourers generally, whose wages are, as a rule, much less than those of skilled tradesmen.

"(2) Those who are unemployed owing to the irregularity of their engagements, such as dock labourers, street porters, &c., who may be said to be always more or less out of work, yet who manage to make a living out of the odd jobs they get."

"(3) Those who are out of employment owing to partial or entire stoppage of works from dull trade."

In both of these classes it is clear that industrious and deserving men may, from time to time, be thrown out of work, and brought to the brink of starvation, and such men are entirely deserving of aid, which should be given preferably in the form of employment rather than in the form of direct charitable relief.

"(4) Those who get thrown out of work owing to their want of skill or through physical inability, for, naturally, no employer can be expected to keep inefficient workers when efficient ones are plentiful."

Mr. R. B. Barclay, General Superintendent to the Board of Supervision, suggests that the above classification is incomplete in the absence of distinct reference to another class, whom I shall place in a fifth division in the terms of his description.

"(5) The chronic unemployed, the dissolute, vicious, worthless loafers, who have no wish or intention at any time to do an honest day's work for an honest day's wage, and whose highest ambition is to procure, by fair means or otherwise, a few pence for a lodging-house bed, breakfast, and supper, when these necessaries are not provided for them out of the public rates in the poorhouse or the prison."

This class includes the professional vagrants, tramps, and beggars, and Mr. Barclay, I think, limits their ambition somewhat too narrowly. Possibly a dinner does not lie within the scope of their aspirations in addition to supper and breakfast, but, assuredly, whisky and tobacco do. I shall add yet another class.

"(6) Discharged prisoners, who, on account of their past record,

and often of physical incapacity or want of skill, have great difficulty in finding work and in earning an honest livelihood."

It is to the solution, in some measure, of the problem presented by these various classes of men that the labour colony system addresses itself. The system is adapted to deal with the condition of honest and capable workmen, or of willing but inefficient workmen, thrown out of employment by fault or accident, and also with that of the discharged criminal, the chronic idler, and the professional vagrant.

It is difficult for men like ourselves, who have lived all our days in comparative comfort, to realise fully the position of men who have been thrown out of employment and are reduced to absolute destitution. If we can for a moment imagine ourselves in such a position, we shall find that the choice of action for the absolutely destitute is limited to a few courses, of which all are bad, and some are desperate. There is suicide, and some have recourse to that dread alternative. There is absolute starvation, and, apart altogether from the multitudes whose lives are shortened by insufficient nourishment, cases do occur in this country—incredible as it seems—of deaths directly produced by want of sufficient food. If an unemployed labourer be unwilling to commit suicide either suddenly and by violent means, or by the slower process of starvation, he may attempt to supply himself with food, either by theft or by begging. The latter is naturally the alternative to which the majority of the unemployed are driven, or which they willingly select. It is the least objectionable of the possible alternatives, but in its ultimate effects it proves most injurious and demoralising. The absolutely destitute man has, therefore, before him only a choice of evils, and no existing agency, according to our present law and conditions, attempts to relieve him from them, or to offer him a better alternative. The existing law of Scotland—perhaps rightly enough—makes no provision for the assistance of an able-bodied man who cannot find work, and who has no means of earning a living. The Report by the Board of Supervision on the Relief of the Unemployed (1893-4) says (p. 4)—"There is no public body in Scotland responsible for the relief of the able-bodied unemployed. . . . There is no statutory obligation on municipal authorities to provide for the unemployed, and it may be urged that they are not entitled to devote any portion of the burgh assessments to the relief of distress either directly or indirectly; and unless they can provide work for the un-

employed which will prove remunerative and of public benefit, objection to such expenditure might be sustained in a court of law. It is certainly illegal to give relief to the able-bodied out of funds administered by parochial boards."

The law of Scotland, therefore, is, that when a man has been starved to the point of illness and incapacity to work, he may be relieved at the public cost; but so long as he retains so much physical strength that he can be called able-bodied, he must be allowed to starve.

The encouragement to crime, but more especially to vagrancy and begging, is obvious. The law may allow a man to starve, but the public heart and the public conscience will not do so. So long as there exist, or can exist, actual hunger and starvation, so long will men continue to practise the habits of indiscriminate almsgiving and indiscriminate charity, feeling that it is better to feed nine worthless vagabonds than to starve one honest man. If the practice of indiscriminate charity, with all its multifarious evils and the encouragement which it gives to fraud and idleness, is to be brought to an end, that can only be done by securing such a provision for all real cases of want as to satisfy the public mind that no man can be left without assistance in extreme need. This is precisely what is provided by the labour colony system. No man, where that system is properly established, can say that he is starving for want of work; and that system, properly applied, and in conjunction with other existing agencies, and supported by the co-operation of the public, is capable of giving a death-blow to dishonest vagrancy, while, at the same time, it gives temporary relief to all honest distress. Labour colonies, planted in sufficient numbers in a country, are modern cities of refuge for the destitute, to which every man may flee whenever, by any cause, he has been brought to poverty, and when he is unable to find work. No man in such a condition is refused in the colonies up to the limits of their capacity.

It is, of course, clear, that in order to destroy vagrancy among the able-bodied by means of the colonies, the support and co-operation of the general public must be obtained; and, perhaps, also the powers of the police to deal with able-bodied and incorrigible vagrants may have to be made more stringent. Neither condition ought to offer much difficulty. The most charitable members of the public do not give willingly to the relief of able-bodied men—they do so under the pressure of the

feeling that the applicant may be deserving; that the pleas of inability to work and of willingness to work may be true; that the hardship may be genuine, and, therefore, that a refusal is impossible. The Rev. Thomas Somerville, of Blackfriars, writing, after an experience of twenty years as a city minister, says he has come to the conclusion "always to help, but never to help without personal and very strict investigation." That is, undoubtedly, a sound principle; but, of all the men who are applied to for charitable aid, not one in a thousand possesses either the means or the time to make such an investigation; and it is obvious that, to most men, it is not only easier but cheaper to give sixpence to an applicant than to inquire whether or not he deserves it. The labour colony system obviates any such necessity. To every such application for help, there is the plain answer, "Go to the farm colony." The honest beggar wants nothing more; the dishonest and inveterate vagrant is driven out of the country.

That is an effect of the system that was well understood by Pastor von Bodelswingh, the founder of the farm colony system, even before the first colony was founded; and to that effect is, in part at least, to be attributed the rapid extension of the system in Germany. "Make your farm colony," he said, in effect, to the people of his province, "and you will drive professional beggars out of the country and into other provinces, where the people will have to start colonies for themselves in self-defence." And this appears actually to have come to pass. The farm colonies, of which there are now twenty-six in Germany, in all parts of the country, have left to the inveterate and incurable tramp only two possible courses. He may allow himself to be put into one of the Houses of Correction by the police, or he may leave the country. The House of Correction forms the supplement to the labour yard and farm colony system, by means of which the strong arm of the law helps the gentle hand of charity; but vagrancy and crime have so much diminished that, though these Houses of Correction are conducted in conjunction with the labour colonies, the total number of inmates has fallen very nearly one-half since the farm colony system came into operation. The vagrants who will not be reformed by the colonies, and who are not willing to risk the Houses of Correction, have been driven into countries where the treatment of beggars has not yet been reduced to a system, and where they can still sue successfully for an undeserved charity. Miss Sutter hints that, on the one side, the German vagrants

have mostly come into England; on the other, gone into Turkey.

The whole problem, therefore, of the chronic unemployed is dealt with by a threefold agency—

(1) The Labour Yard in the cities;

(2) The Farm Colony in the country districts; and

(3) The House of Correction for the discipline, control, and punishment of vicious and incorrigible vagrants.

The labour yard in the city ought to be regarded mainly as the entrance door to the farm colony. One has recently been opened in Glasgow by the Charity Organisation Society. It forms an essential branch of the whole scheme, because it is in the cities that the unemployed are found in largest numbers, and it would form no reply to an applicant for aid within the city to direct him to go to a farm colony situated at a distance of thirty miles or more. Neither would it be wise to undertake the expenditure of sending a man to a distant colony till his willingness to work and his capacity to work have been tested. One or more labour yards in a city are essential. The applicant who says he wants work and cannot get it can be sent at once to the labour yard. There his character and fitness will be proved, and thence he can be sent to the farm colony. But, on the other hand, the labour yard of itself must not be regarded as supplying all that is required. It is just possible that, in Glasgow, those who have promoted the formation of the labour yard may stop at that point, and forget that it is only the first step. To meet all the conditions of the problem, the farm colony is even more necessary. In Berlin there exists just such a labour yard or labour colony, and the pastor and inspector there have joined in urging, as a conclusion forced on them by their experience, that no labour colony should be instituted in a city without a farm colony attached to it. There are many reasons for this, but first and foremost stands the difficulty of providing work in the labour yards. Variety of work is wanted, in order that it may be suited, as far as possible, to the capacity and skill of each entrant, and especially is it desirable that there should be abundance of labour suitable for unskilled men. In the labour yards the provision of such work is found to be a matter of great practical difficulty, and, to overcome it, there is always liable to be unfair competition engendered with other trades carried on in the city. But there also a much greater difficulty found in controlling and managing the men in the labour yards than on a farm colony. Their

enclosure in large numbers within a confined space inevitably produces this difficulty. In the Berlin Labour Colony, of 551 who left the colony in the years 1883-6, there were—

69 dismissed for laziness, infringement of rules, &c.
40 „ drunkenness.
10 „ uncleanliness.
9 „ incapacity to labour.

In all, 128, out of 551, or over 23 per cent., were dismissed from the city labour colony for bad conduct of one kind or another. On the farm colony of Rickling, in 1890-91, the character of the colonists was described as being unusually bad, but, out of 383 men who left the colony in that year, only 15 were dismissed for bad conduct, or incapacity to work, or less than 4 per cent. In a confined space of a few rooms or buildings in a city, the control must necessarily be of a more stringent and irksome character, if order is to be maintained at all; but the more stringent the rules, the more frequently must they also be transgressed, and the less does the labour yard assume the character of a friendly home, the more the aspect of a hated prison.

If it were the object of the scheme to deal only with capable and honest workmen wishing to remain on the colony as short a time as possible, and anxiously looking for employment outside the city, labour yards might more fully meet the requirements of the case. But the honest workmen form only a moderate proportion of the whole numbers who enter a labour yard. The majority of the colonists belong to the more degraded classes of the unemployed, and the colony has to do much more than give them a temporary helping hand. The majority of the colonists are physical and moral wrecks. Their bodily strength has been sapped by hunger, by exposure, often by dissipation and vice, while their moral degradation may have been either a cause or a consequence of their physical ruin. It is the object of the colonies to give back to the men their physical health and strength, to restore their self-respect, to wean them from habits of vice, to train them in habits of order, industry, and thrift. But in what respect are the conditions of a labour yard in Glasgow, or in any large city, suitable for the restoration of physical health? The crowding, the confinement, the nature of the work, and other conditions, are all against it. Assume that every proper sanitary regulation receives careful attention, and that the conditions are made as suitable for the mainten-

ance of men in health as they are for workmen generally in our cities. But the question is not so much one of maintenance of the health already enjoyed, as of restoration of strength to men previously much weakened and reduced. How will a labour yard in the damp, dark, and impure atmosphere of this city compare as a sanatorium with a farm situated on one of our open western uplands, and blown over by the bracing Atlantic breezes? The mere absence of sunlight from our smoke-covered city, is of itself, in my opinion, enough to condemn it; for the common association of goodness with light, and of evil with darkness, is a poetic imagination that has a basis in a sound, though perhaps even yet insufficiently apprehended, physical fact. Altogether, the conditions of a farm colony are so much more favourable than those of a city colony for the physical and moral improvement of the colonists that their relative efficacy need not be further compared. In the remarkable work carried on by the Salvation Army in London, the conjunction and co-operation of these two agencies has formed from the beginning the main essential feature of its scheme. In the same way must the fact be emphasised that the labour yards, of which the first has now been opened in Glasgow, will not and cannot deal with full efficacy and success with the problem of the unemployed and the submerged, unless there be associated with them farm colonies as well.

In regard to the nature and amount of success that has been actually attained by the labour colony system, a few words may be said. The strongest evidence of the success of the colonies lies in their rapid extension among a people so economical and so practical as the Germans. The first colony was instituted in 1882, only twelve years ago. There are now twenty six such colonies in Germany, scattered over the length and breadth of the land, and 10,000 men are said to pass annually through them. England and Switzerland have one each, and in both those countries more are projected. Three have been started in Australia. France, like Scotland, has, so far, contented herself with making inquiries, but the report of a French committee of investigation has been as favourable as that of the Glasgow committee sent out two years ago by the Association for Improving the Condition of the People.* It seems impossible,

* A commission recently appointed by the Town Council of Liverpool to inquire into the subject of the unemployed, makes the recommendation, among others, that a labour colony or farm should be established.

in face of that rapid extension of the system, even to question its success, but so many meanings may be attached to that word that it may be well to indicate more exactly in what the success consists. If the effect on vagrancy only be considered, here is Miss Sutter's statement:—"The great mass," she says, "of starving vagrants that formerly accosted you at every turn have practically disappeared from the country." It has been said that since these colonies were instituted in Germany crime has diminished 30 per cent., and the inmates of the Houses of Correction fell in the five years (1885-90) from 23,000 to 13,000.

In regard to the proportion of fallen men who are permanently reclaimed and restored to respectable life by means of the colonies, the testimony naturally varies. But, apart from the question of permanence, the temporary benefit derived by the men from a residence on the colonies is itself a great good. The duration of residence on the colonies varies considerably, but, on an average, may be put at three months. For three months, then, by means of the colonies, idle, vicious, and depraved men are made to live useful lives and to do useful work. They are made to provide for their own maintenance, they are forced to buy their own clothes, and they become in some measure accustomed to labour, and restored to habits of industry and self-respect. They are kept from the temptation to drink, their tendencies to vice are held in check, and they have little opportunity for crime. On the very lowest view that can be taken of the work of the colonies, they, for a time at least, restrain men from vice and crime; they make them partially pay for their living; and they utilise their labour so as to convert many acres of worthless soil into land that will for generations repay cultivation, and that thus forms a permanent addition to the wealth of the country. But there is, besides, a unanimous evidence that a number of the men are not only restrained from bad conduct for the time, but that they are permanently reclaimed from useless, wandering, and often criminal living, and transformed into well-conducted, laborious, and useful members of society. "The colony," wrote the late Emperor of Germany of the first colony, that of Wilhelmsdorf "has proved its efficiency by rescuing from utter perdition hundreds of the sunken and lost, and leading them back to orderly and industrious lives." What the actual percentage of permanent reclamations may be is difficult to say. Various estimates have been given by different superintendents. One intelligent

official in the Rickling Colony was positive in his opinion, that at least 25 per cent. of the colonists were permanently restored to respectable life. But let the percentage be estimated much lower. Suppose that only 10 per cent. of all the colonists are permanently brought back to honest and useful living. About 10,000 men pass annually through the seventy-six German colonies, and if 1,000 of these be raised from the ranks of the submerged, that result alone, apart from all else, might be held to justify the whole expenditure on the colonies.

And that brings us to a consideration of the cost of the system. On this point it is obvious that the experience of the German colonies can hardly be regarded as offering conclusive evidence of the cost that might be incurred in this country, but neither is there such a material difference in the conditions as to render valueless the information derived from the German colonies. It is true that the capital required to institute a farm colony in Scotland is much greater than in Germany, or in parts of the South of England, because, in spite of the universal extent of the agricultural depression, land has nowhere in Scotland fallen to the same low level of capital value as in those countries. Further, as it is very essential to the success of a farm colony that the property purchased to be formed into a colony should possess a number of features of a special character, a farm for the purpose cannot be purchased merely because it happens to be in the market, and happens also to be cheap. The suitableness of the property for the purpose required is of so much importance that, at any reasonable cost, a farm fulfilling the requisite conditions must be obtained, and that being so, the chances of its being cheaply purchased are much lessened. Of a number of farms inspected by Mr. Speir, of Newton, and myself, in the West of Scotland last winter, we found only one that appeared to be in all respects suitable for the purposes of a colony, and that one the proprietor declined to sell. We made subsequent recommendations in the order of suitableness. But the question of capital need not enter into our estimate, because, under the ordinary conditions of labour colony farms, the full capital value originally invested is not only conserved, but, in general, is very largely increased. It is indeed held on some of the colonies, where the reclamation and improvement of land have formed a principal feature in the management, that the annual deficit is fully repaid in the increased capital value of the property. This may be questionable; but, without doubt, a

great proportion of the annual deficit on a properly-selected farm colony is not lost, but is invested in increased capital value. The amount of the annual deficit depends very greatly on the kind of farm selected, and on the general suitableness of its conditions, and the selection of a suitable farm is, therefore, an initial step of the greatest importance. The objects kept in view in the selection are two—(1st) that the farm should be capable of giving regular employment to a large number of men; and (2nd) that it should be capable of giving such a return for the labour expended on it as to render it as nearly as possible self supporting.

The conditions required in a farm to fulfil these objects are as follows:—It should contain a considerable tract of land suitable for vegetable and fruit cultivation. The growth of vegetables and fruits requires much hand labour, and gives a very good return for the labour expended. A tract of clay suitable for brick and tile making is very desirable, as unskilled labour can be readily employed in the digging and conveyance of the clay. A tract of peat capable of providing fuel is also useful, and a large area of poor land that is capable of being converted by some available means into good land is a condition of the first importance. On the proper fulfilment and adjustment of these conditions on a farm colony the ultimate cost of the system chiefly depends. Much, of course, also depends on the skill of the management, and on the judgment exercised in utilising to the best advantage the large amount of unskilled labour available. Much likewise depends on the observance of a proper adjustment between the number of men placed on the colony, and on its capability to provide them with food, and with work that will give an adequate return. If the men cannot be employed wholly in work that gives a good return, and if their labour has to be largely turned into less remunerative channels, then the total deficit and the proportionate cost per man are correspondingly increased.

The mere size of the colony is an important point that affects considerably, not only the cost per man, but also the efficacy of the reforming influences. In the proposals of the Glasgow Association for Improving the Condition of the People, a somewhat large colony is contemplated, requiring a capital outlay in the first year or two amounting to somewhat less than £20,000. It has been frequently suggested that a commencement should be made on a smaller scale, and that the scheme, if found successful, could then be extended. If there were any possible doubt of the success of a

farm colony, the suggestion would be a wise one, but, unless through the entire ignoring of the necessary conditions of success, or through the grossest incompetence and mismanagement, there is no room, according to my judgment, for the consideration of even a possible failure. The institution of a farm colony in Scotland would be no more a fresh and new experiment than was the institution of the Salvation Army colony in Essex. Both are merely further extensions of an established and successful system that is now quite beyond the scope of mere experiment. Therefore, to begin a farm colony in Scotland on any other plan or of any other size thân that which has been proved by experience to be the best, would be to foolishly ignore one of the admitted conditions of a complete success. The size of the German colonies and the number of men that they are capable of receiving vary considerably; but their experience shows, as I was assured by a superintendent well qualified to form a reliable judgment, that the best size of colony was one capable of receiving about 150 men. The objections to a smaller size of colony are—(1st) the very obvious one, that the expense of management is proportionately greater; and that (2nd) the difficulties found in the practical management of a smaller colony are much greater and harder to overcome. The smaller farm affords less room for variety of cropping, and there is greater difficulty in providing work at all seasons of the year for all the colonists. There is less of the extra work, of the kind so desirable on a farm colony, that can be dropped or resumed at any time according to the supply of workers. Other labour difficulties are found also on the smaller colonies, of a serious practical character, so that, alike in cost and in efficiency of management, the smaller colonies compare very unfavourably with the larger; and to begin the scheme on a small scale is to sacrifice, to a certain extent, both efficiency and economy. On the other hand, if the colony be too large, it is apt to exceed the capacity of the superintendent to conduct all its operations properly, and to oversee all its residents. In order that the colony should produce its full moral effect, it is necessary that the superintendent should become well acquainted with each colonist, and that the colonists should all be brought under his personal influence. As the men resident on the colonies are, for the most part, constantly changing, the limit of 150 men does not appear to be too small for this purpose. In the larger colonies the same end may be doubtless in a measure achieved by efficient under-officering, but it is preferable that such work should not exceed the capacity of the superintendent himself.

It will be obvious enough, from the various conditions mentioned as affecting the cost of the colonies that there is room for a great diversity in their financial experience. Only one, so far as I have seen, is reported to be self-supporting. The farm colony of Magdeburg is said to have paid its way from the second year of its existence, and this is attributed to the fact that the farm has been largely managed as a market garden. In respect to suitability of conditions and adaptation to the various requirements, the colony of the Salvation Army at Hadleigh, in Essex, would be hard to excel.

Mr. Harold Moore, a very capable and reliable authority, is of opinion that this colony may be made self-supporting, and I am by no means convinced that this is impossible.*

In all the German colonies that I have visited, there is a large annual deficit, which appears to vary usually from about £8 to £15 for each man kept on the colonies for a year. On a well-selected colony of sufficient size, it does not exceed £12.

If the average duration of residence of the men on the colonies be put at three months—though it varies extremely,—the actual cost for every man aided is one-fourth of that amount.

It has been already pointed out that much more capital would be required to initiate a colony in Scotland than in Germany, but, nevertheless, the difference between annual income and expenditure on the colonies, and consequently the cost per man, should be much the same in both countries. This is so chiefly because the colonies are in large measure self-contained in their management. The farm feeds its own colonists with its own produce, and though the produce, if purchased, would cost more in Scotland than in Germany, the quantities eaten by the colonists will not show the same variation; or, if there be a variation in the amount of food consumed, I think the Germans will carry the palm. In regard to such purchases as must be made, the cost will be greater in this country; but, on the other hand, the returns obtained for any produce sold off the farm will also be greater. I am, therefore, of opinion that the cost per man in Scotland, as in Germany, on a

* The above sentence was written prior to 19th December last, the date originally fixed for the reading of this paper. In January was issued Mr. Bramwell Booth's report on "Work in Darkest England in 1894," which says, p. 51, "The most satisfactory part of the accounts is of course the fact that so far as the agriculture, the work on the land, is concerned, the year's operations show a profit of several hundred pounds."

properly-selected colony of suitable size, should not exceed £12 per man per annum, and it might possibly be much less.

Can that cost be regarded as excessive, or as so great as to stand as a conclusive objection to the system? Perhaps the answer to that question is best given by considering what the man costs *off* the colony as well as *on*. At the average of £12 per annum, the vagrant on the colonies costs the country somewhat less than 4s. 8d. per week. I have no information as to the actual cost to the country of a vagrant wandering along our roads, and I do not know whether reliable statistics on such a point are available.* But, at any rate, the professional tramp is kept in life from year to year wholly at the expense of the country; he works none, contributes nothing to his own maintenance, and is wholly fed and clothed by public charity. It does not appear to me that the direct cost of supporting able-bodied vagabonds wandering round the country can possibly be less than 4s. 8d. per week; but there are, in addition, the indirect costs, the increase of crime, the larger prisons, the larger police force, the greater expenditure involved in the administration of justice and the infliction of punishment, the damage to property and even the danger to life. On the money basis alone, it is certain that the country, by instituting labour yards and farm colonies, would every year be the richer by many thousands of pounds.

If the suggestion be made that a cheaper system of relieving the unemployed might be found, the results of this method may be compared with one other recently attempted in Glasgow. During the winter of 1892-3, the magistrates of this city found it necessary to take special measures for the relief of the unemployed. Work was provided for them for seventy-four days in stone-breaking, trenching, and digging, and subsistence wages only were paid. The whole cost incurred was £3,103; the value of the work done was estimated at £1,402; and the deficit was, therefore, £1,701. The average number of men working was 467, and the cost per man per annum was £17 19s. The cost on this method of relief has been therefore double what is incurred on some of the farm colonies, and a third more than the average cost on them, altogether apart from the fact that a part, and in some cases a large

* Mr. Bramwell Booth says in his report quoted from on last page—"The cost of the loafing, idle, and vicious can't be estimated. . . . They consume and do not produce. They eat, but they do not labour."

part, of the expenditure on the colonies is recovered in the enhanced value of the improved land. But, compare the methods in point of efficiency. In the one, there is mere temporary relief; there is no attempt at the permanent provision of work, and there is no attempt to improve or to elevate the men either physically or morally. In the other, there is constant personal supervision and oversight; there is the removal of drink and other temptations; there is the healthy moral atmosphere; there is the never-ceasing effort to instruct and to reform; there is the assistance given in finding permanent employment. If these and all the other points of contrast be duly considered, even at the maximum costs incurred on the farm colony, the comparison, alike in efficiency and economy, is altogether to its advantage.

But there is a feature in the farm colony system of a still more important character in relation to the assistance of the unemployed. Such efforts as that described in Glasgow are only spasmodic and occasional. They do not assist chronic distress or meet the chronic difficulty. They are intended only for periods of special distress and of clamant urgency. They are not devised for the relief of the individual, but for the relief of the masses in exceptional times. Single starving men may starve and no one inquires, dozens may starve and no one interferes; it is only when hundreds or thousands are idle that any such effort to help is made. The labour colonies, on the other hand, are always available; they prevent the accumulation of masses of starving men, for, as each man finds himself out of work and out of means, he can get work and food at the colony. The labour colony system forms, therefore, in every way, the most effective and most economical method that has yet been devised of dealing with the difficult problem of the vagrant and the chronic unemployed.

VI.—*Notes on the Scottish Poor-Law, the Unemployed, and Labour Colonies.* By Jas. R. Motion, Acting Inspector, Barony Parish. *(A communication from the Economic Science Section.)*

[Read before the Society, 6th February, 1895.]

The Scotch Poor Law is now nearly fifty years old, the Act of Parliament embodying its provisions having been passed in 1845. That Act, with several amending Statutes of minor importance, remains intact to this day. The recent Local Government Act, while creating new bodies for carrying out these provisions, makes no change in the general administration of the Poor Law.

It is needless to examine the causes which led to the creation of the Poor Law Act: it is too old a story to refer to here, and is not pertinent to the subject.

Nor is it necessary, I think, to describe the machinery by which the Act is carried out, further than to state that the Parochial Boards in each parish are responsible to the ratepayers for the administration of the affairs of the parish, and that the inspectors of poor are the executive officers of these Boards.

Notwithstanding the great changes which have taken place in the population, wealth, distribution of employments, and various other considerations, it is remarkable that this Act of fifty years' standing has so well met the requirements of the country. Particularly during the last twenty years the Act has had its effect in a great diminution of pauperism.

The only point where there may be a difference of opinion is that the Act has not met the case of the able-bodied poor. But it must be remembered that the Act was not long in force when the highest courts of the country held that Parochial Boards could not give relief to the able-bodied, and that dictum has prevailed till this day. All the same, it is true that the Board of Supervision advised a reasonable interpretation of this decision, which is fairly carried out by the Parochial Boards when they come to consider the whole circumstances of individual cases.

No paper upon such a subject as this can be complete without reference to statistics, but I shall refrain as much as possible from loading my paper with figures.

First, then, for convenience, I shall take the official reports for the years 1873 and 1893 (the last published at this moment), as to the total comparative expenditure, valuation, population, &c., over the whole of Scotland, namely :—

YEAR.	Expenditure for the Relief and Management of the Poor.	Valuation or Rental.	Rate of Expenditure per cent. and per £1 of Valuation. Per cent.	Per £1.	Estimated Population, founded on Census Returns.	Rate of Expenditure per head of Population.
	£	£	£ S. D.			
1873.	801,895	19,199,665	4 3 6¼	10d.	3,434,902	4/8
Of which Lunatic Poor, - -	136,685					
Exclusive of do.,	665,210		3 9 3½	8d.		3/10¼
1893.	873,947	24,180,483	3 12 3½	8¾d.	4,083,661	4/3¼
Of which Lunatic Poor, - -	256,881					
Exclusive of do.,	617,066		2 11 0½	6d.		3/0¼

These figures disclose a satisfactory state of matters, for while we have an increase in the valuation of £4,980,818, and an increase in the population of 648,759, the rates of expenditure per cent., per £1 of valuation, and per head of population, have decreased by 11s. 2¾d., 1¼d., and 4¾d., respectively—notwithstanding the cost of the insane, which has nearly doubled. Or, to put it another way—excluding the cost of the insane poor from both sets of figures, the decrease would have been 18s. 3d., 2d., and 10d., respectively.

The number of poorhouses in Scotland, with their licensed accommodation, and population at a given date, still further show the decline of ordinary pauperism in these years, namely :—

Year.	No.	Licensed Accommodation.	No. of Inmates at 30th June.	Estimated Population of Scotland.	Proportion of Inmates to Population.	Per cent.
1873	62	14,375	7,371	3,434,902	1 in 466	0·21
1893	66	15,186	9,084	4,083,661	1 in 449	0·22

Similar figures for the three parishes in Glasgow show the following results :—

Parish.	Year.	Licensed Accommodation.	No. of Inmates at 30th June.	Population.	Proportion of Inmates to Population.	Per cent.
Glasgow, -	1873	1,500	1,099	170,553	1 in 155	0·64
	1893	1,543	1,336	176,824	1 in 132	0·75
Barony, -	1873	1,348	756	234,115	1 in 309	0·32
	1893	1,427	1,033	309,812	1 in 299	0·33
Govan and Gorbals, -	1873	600	429	161,564	1 in 376	0·26
	1893	808	688	286,281	1 in 416	0·24
Totals, -	1873	3,448	2,284	566,232	1 in 247	0·40
	1893	3,778	3,057	772,917	1 in 252	0·39

These returns indicate that the state of pauperism in Glasgow is about the same for the two periods, and they disclose the fact that the class of poor requiring the care and attention of the Parochial Boards, within the precincts of the poorhouse and hospital wards therein, has rather increased than diminished; and also shows, from the previous return, that the increase in numbers has not had the effect of increasing the cost of relief and management.

Let us now consider what class of persons are relieved by Parochial Boards. They are:—

First: The decent, respectable poor—aged men and women, both married and single; widows with children, who have homes of their own, and who are more or less able to earn a small sum per week; and orphan and deserted children.

Second: The aged, infirm, and sick, who have no home, are unable to take care of themselves, and who require nursing, or those whose families refuse or neglect to give them a home or any assistance whatever.

Third: Deserted wives, women with illegitimate children, and men and women of idle, dissolute, and depraved habits.

Fourth: The insane.

The first class, or the decent and respectable poor, &c., are

assisted by means of out-door relief, which is a supplement to what they and their families may be able to earn; and in the case of the aged, is a supplement to what their married sons and daughters and other relatives (who are themselves unable wholly to support) may be able to give. The amount of these out-door allowances depends entirely upon the circumstances of each individual case.

Under this head it has also to be noticed, that many fathers or mothers are forced to apply to the parish, because their own children, their own flesh and blood, refuse and neglect to provide for them in any shape or form. It is painful to observe the callous nature of these people, when one sees them considering how little they can possibly give for the support of their aged parents when brought before the committee of the Board.

Orphan children are boarded in the country with carefully-selected guardians, after a short period of probation in the poor-house, and the children who have been deserted by the surviving parent, or by both, are also boarded in the country, after every effort is made to apprehend and punish the parents. For the year ending May, 1894, 49 children, deserted by parents, were thus received into the poorhouse previous to being boarded out.

From a return prepared for my Board in May, 1894, it appears that the results from the boarding-out of our pauper children are highly satisfactory, and reflect credit upon the guardians and their careful upbringing.

The following statistics show the number of children taken off roll and sent to work, &c., during ten years ending 14th May, 1892, also their whereabouts, characters, and occupations:—

	Males.	Females.	Total.
Number of schedules sent out to guardians,	238	264	502
Returned through post-office "not found," guardians having died or removed, -	5	21	26
Returned by guardians who could give no information, - - - - -	15	12	27
Conduct reported on by guardians as satisfactory, - - - - - - -	214	229	443
Conduct reported on by guardians as doubtful or unsatisfactory, - - -	4	2	6
Total, - - -	238	264	502

The two latter classes were located thus:—

	Males.	Females	Total.
In Glasgow,	44	80	124
Elsewhere,	160	139	299
Emigrated,	14	12	26
Total,	218	231	449

Their occupations were—

	Males.	Females.	Total.
Trades (various),	63	6	69
Farm servants,	63	16	79
Miners,	32	...	32
Labourers,	26	...	26
Factory workers,	6	28	34
Clerks,	7	4	11
Soldiers,	8	...	8
Sailors,	4	...	4
Clothier, in business for himself,	1	...	1
Commercial traveller,	1	...	1
Domestic servants,	...	170	170
Teachers,	...	2	2
In Woodilee Asylum (insane),	...	1	1
Returned to Poorhouse, leg requiring amputation,	1	...	1
Died,	6	4	10
Total,	218	231	449

It may be interesting to note that 5 of the boys and 17 of the girls subsequently married and are doing well.

Many of the children who have been boarded out become useful citizens, and rarely forget their foster-parents, whom they visit in after life in company with their own children.

The experiment of separating children from their abandoned parents who went in and out of the poorhouse twenty to thirty times in a year, combined with that of removing from the poorhouse the children of inmates of the hospital who were past recovery, and boarding them in the country, has also been of a gratifying nature, as the following figures will show. The number of parents relieved by the Board from November, 1884, till May, 1893, was 270, involving 488 children—

Of these parents there were—

In poorhouse, and subsequently discharged,	191
On out-door roll, and subsequently struck off,	41
In Woodilee Asylum (insane),	12
Parents on out-door roll who had lost control of their children,	26
Total,	270

Of the above, 73 were bastardy cases—6 being deserted wives, 12 widows, and 55 single women.

The results as regards parents relieved—

Still chargeable, owing to ill health,	12
Ceased to be chargeable,	224
Returning at irregular intervals,	34
Total,	270

Results as regards children—

Children still on roll,	287
Off roll, to situations or otherwise,	92
Circumstances of parents improved, and children handed back,	42
Handed over to parents who had subsequently married,	21
Adopted by guardians,	9
Handed over to parents, father being apprehended,	13
Married,	1
Became a soldier,	1
Sent to hospital,	2
Died,	5
Handed to putative fathers (after due inquiry),	4
Transferred to out-door roll,	4
To father in America,	4
Adopted by strangers,	3
Total,	488

The second class, or the aged and infirm poor, are provided for in various departments of the poorhouse:—(1) In the hospital, where there is a fully-equipped medical staff as well as a staff of trained sick nurses; (2) in the infirm wards (also under the charge of trained nurses), where they are carefully classified as far as the circumstances and the buildings will allow, and where they have far greater comfort, better dietary, and more care than they could get outside, even with out-door relief. This, at all events, applies to the large city poorhouses.

In the third class—deserted wives, &c.—the one which costs more to the parish than any other (except the insane), nearly all are as bad as the men. It is found frequently when the husbands have been apprehended on the charge of desertion that no conviction could follow, in respect that the wives were frequently the worst offenders because of their drunken habits, and also regular termagants.

The majority are the wives of drunken scoundrels, who too frequently abandon them, and are found in the model lodging-houses which now bulk so largely in the lower life of this city. The occupations of 272 husbands of such women as applied for relief last year included 78 general labourers, 36 ironworkers, moulders, &c., &c.; 24 seamen, firemen, &c.; 13 belonging to the building trades, 8 tailors, 7 carters, 16 miners, 10 shoemakers, while the remainder of the 272 cannot be classified.

It is no uncommon thing for the officer to find a deserter enjoying a game at bagatelle, or at a Saturday evening concert in a "Model," while his wife and children are huddled together in a miserable single apartment, without a bed or a stick to sit upon, and with not a vestige of fire.

The average number of deserted cases per annum is 279, and in these we are practically powerless. The husbands may be apprehended and punished, but they go off again and again. Meantime the children struggle through, and those who survive frequently come to us by the death of one or other of the parents; or, as frequently happens, they are ultimately boarded out, their parents having both become frequenters of the poorhouse. The conduct of these parents accounts in a very great measure for the high child death-rate which prevails in the city.

In this class, too, bulk largely the women with illegitimate children. The young, innocent women, who, happily, are few, are provided for and taken in hand by many charitable agencies throughout the city. Those who appear most frequently in our books are the hardened, brazen-faced females, with sometimes as many as six children to more than one father. They live in cohabitation outside, and when the woman requires the shelter of the maternity ward, her paramour disappears till she takes her discharge; and so the round goes on. The children rarely live beyond infancy.

It is nothing unusual for a paramour to call for a visiting line to see his "sister," and when recognised, or after cross-examination by the officer in charge, he bolts from the office.

In this class we have also men and women who have come to need the shelter of the poorhouse through their own fault, brought about by drink and debauchery. These cases do not come from the ordinary working-classes of the city, but from what are now called the "submerged." Such persons have scarcely ever done a day's work. They are mostly the offspring of the lowest class of

the poor, and have never had the vigour or the head for work; they are the "weeds" even of this class, and, when they fall a prey to drink, they become utterly hopeless, and go in and out of the poorhouse. They search for work, which they never find, and return in a few weeks as weak and helpless as ever.

Out of a total of 3,685 persons admitted to Barnhill Poorhouse last year, 427 males, 46 females, and 6 children—in all, 479, or 13 per cent.—came from model lodging-houses; while 64 males, 42 females, and 66 children—in all, 172, or 4·66 per cent.—came from police offices; and 51 of these persons suffered from venereal diseases, acute and chronic.

Out of a population in the poorhouse of 1,033 on 14th August last, 117 (51 males and 66 females) may be classed as the idle, depraved, and drunken. Included in this class are men and women who leave the poorhouse and go on tramp over the country. When they run down, they apply to the nearest inspector of poor, who has to return them to their own parish; or, after a few days' rest, they proceed on their journey to some other town, and repeat the process.

In 1893, 66 of our well-known Barony cases, with six dependents, were chargeable to parishes as far separate as Peterhead and Dumfries. Of the 66 cases, 53 were males (one only had a wife), while 13 were females. It is to be noted that very few children are included in the above category; the paupers generally comprise the class known to inspectors as certified "partially able for work," and range from 20 to 70 years of age. These are the men you meet with on the country roads who are out of employment, and on the tramp for work, but they have done no work for years, as an examination of their hands will testify. They are certainly on tramp, but not for work. A well-known character was certified unfit for work, footsore, &c., and the medical officer of the country poorhouse recommended that he be allowed to remain there for a month till the weather improved. Two days after his discharge he turned up in another poorhouse 40 miles distant.

Fourth, and lastly, we have the care of the insane, who are becoming a vast army, and who chiefly add to the cost of the relief and management of the poor.

Parochial Boards are bound to provide for all certified lunatics whose relatives are unable to pay for their maintenance in public or private asylums. In certain cases Parochial Boards have power to recover from relatives, legally liable for their maintenance,

sums varying from 1s. to 9s. per week—such as a husband for a wife, or a father for a daughter or son. Last year the sum recovered by my Board from relatives amounted to £842, out of a cost to the Board for the maintenance of lunatics in asylum of £15,864, the average number resident being 621.

It is astonishing to find the excuses offered and the subterfuges resorted to by many of their relatives to escape payment of these charges, which are fixed after careful inquiry into their circumstances.

It seems to me that it is time that some new departure was taken to curtail and further define this enormous class, who, on 1st January, 1894, numbered 11,193. Of these 6,005 were provided for in royal and district asylums—the cost of the erection of the latter being defrayed out of a lunacy rate not included in the poor-law returns; 1,614 were lodged in parochial asylums; 857 in lunatic wards of poorhouses; 2,565 were boarded in private dwellings. It has been stated in the course of an inquiry into the subject of accommodation that two possibilities exist for dealing with the problem—(1) methods for checking the income of unsuitable cases, and (2) methods for facilitating the egress of suitable patients.

There are very many unsuitable cases constantly sent to asylums for treatment which might all be treated outside of an asylum with benefit to themselves and to the community. I refer to cases of alcoholism, physical breakdown, senility, &c. Then there is no uniform standard of medical opinion as to what constitutes insanity. My Board some years ago tried to remedy this, and appointed one of our medical officers to certify all insane cases, and when considered doubtful they were sent to a ward at our poorhouse, where they were placed under observation. The advantages of such a scheme are that uniform experienced medical opinion is passed upon all cases of pauper insanity, and that a large number of doubtful cases never reach the asylum.

I therefore venture to say that there is necessity for some reform in the care and treatment of the insane poor. What that reform should be I do not care to state, but I have hopes that the system adopted in the Barony Parish, if extended to every other parish or group of parishes, would tend to put a check, at all events, upon the influx of new cases to asylums, while the extension of the private dwelling or boarding-out system throughout every lunacy district would remove from asylums those chronic, harmless

cases that at present crowd these institutions, and thus make room for those requiring immediate and active treatment.

My experience of the operation of this part of poor-law administration is that, in a large number of villages and hamlets throughout the country, we have an excellent class of very decent country people with whom good family homes could be secured for this class of the harmless insane. Such are of great benefit to the patients, by bringing them back to the influence of home, &c., and the system is also of considerable benefit to the inhabitants of these villages, financially and otherwise.

This subject of pauperism might be still further enlarged upon, but we must not overlook the other points of the paper which have more or less a bearing upon pauperism, and specially old-age pensions and the unemployed. In this connection it may be useful here to refer to a report by a Committee of the Society of Inspectors of Poor of Scotland, dated 31st January, 1894, which was appointed to consider and report upon the various state-insurance or old-age pension schemes then before the country, on the statistics applicable to Scotland upon which such schemes were founded, and on the advantages or disadvantages likely to accrue from the adoption of either of the schemes in their relation to pauperism.

That committee issued elaborate schedules of inquiry to a large number of inspectors of poor of typical parishes. The returns were collated and printed in abstract form, with analysis thereof. Copies of the report may be had from the Secretary, Mr. Wallace, Inspector of Govan Combination.

It appears to me that an unconditional old-age pension to all persons of 65 years of age and upwards would involve a very large expenditure of public money on behalf of a great many people who do not require such a pension; while, if the pension is conditioned upon annual payments, or even slump payments, it would only be taken advantage of by the better class, who could mostly do without it, and the great bulk of the poorer classes would be left as they are. The report to which I have referred shows that none of the state-insurance or old-age pension schemes proposed would materially mitigate the evils of pauperism, in view of the fact that there are apparently only 16,662 at this age who require assistance, out of the total number of 203,096 who are above 65 years of age in Scotland. It also proves that the greatest amount of pauperism in the country exists from the chargeability of

persons under 65 years of age, and that any scheme which simply provides for those above that age would do comparatively little to reduce pauperism, and that, consequently, the arguments of the advocates of such schemes that their adoption would do away with pauperism is fallacious.

In his latest speech on this subject, delivered at Birmingham to friendly society officers, Mr. Chamberlain declared that the percentage of pauperism to total population over 65 years was in England 29·28, or one in 3½, compared with which Scotland gives a totally different result—namely, 11·29, or one in 9.

The "Unemployed" has been a subject of discussion and writing which seems to be endless, and the more it is discussed the more perplexing it becomes. The question has been ably treated by Mr. R. B. Barclay, of the Local Government Board of Scotland, in a report to that Board, for the information of the Secretary for Scotland, on the relief of the able-bodied unemployed during the winter of 1893-94 (Parliamentary Paper, C 7410, 1894); and it would be well to refer to that report to learn what is understood by the local authorities and officials whom Mr. Barclay interviewed by the term "unemployed," and also who and what they are. But, in addition to the definitions quoted in that report, I wish to state another which Mr. Barclay specially notes, and which, shortly, includes dissolute, vicious, worthless loafers, who have no wish to do an honest day's work for an honest day's wage, and who wish to procure, by fair means or otherwise, a few pence for lodging-house bed, &c., when their wants are not provided for them out of the public rates.

I have a confidential report before me written by one of my assistants who was actively engaged in the relief of the unemployed in 1884-85. He says the inspectors of poor were called upon to assist in the investigation of applications, because of the great number of undeserving cases that had appeared on the scene in 1879. These, he says, were men who never worked, and also men who came in from all parts of the country to participate in the soup kitchens, &c. During the winter of 1884-85 he visited several hundreds of so-called unemployed in different parts of the city, but came across very few respectable tradesmen, and those who did apply refused to work or mingle with the class of men at the labour depôts, on the ground that they were chiefly composed of the model-lodging class. As a test, he recommended that stone-breaking should be given to the doubtful cases. I would also add

yet another class who take advantage of the unemployed cry every year. I refer to those men who are leaving H.M. prison at Barlinnie every lawful morning. These men have been sent there, not only from the Glasgow courts, but from the local courts of a large area outside the city, and these men, when they get their discharge, go to swell the ranks of the so-called unemployed.

From the report of the proceedings of the meeting of the Prisoners' Aid Society for December, 1893, I find it stated that for the year ending 31st March, 1893, there were discharged from Duke Street Prison 5,439 men and 5,784 women, while 13,266 men were discharged from Barlinnie—a total of 24,489. "With the stigma of imprisonment on them, it was difficult for these people to get into situations." There is just the point—are they to be allowed to beg? are they to starve? what can be done with them? Is it not also a question why they have got the stigma of imprisonment on them? And, having acquired it by their own evil conduct, with their eyes open, should they not be made to work it off to their own salvation? Why should the charitable public be called upon to keep thousands of unmitigated scoundrels, 40 per cent. of whom appear in jail from one to four times per year, while there is no attempt made to help the well-doing tradesman unconnected with a trades union, who, through no fault of his own, is thrown out of work, and who, with a delicate wife and young children, may gradually sink into despair and an early grave, leaving his widow and children paupers.

Such cases ought to be known to every clergyman and town missionary, and every effort should be made to direct, guide, and help them to employment; indeed, these cases would not be so numerous if the waifs and strays of society were provided for as detailed further on, and the regular employment of these deserving people would not be threatened by the cheap labour of such casual workers.

I cannot overlook, however, the question of these abandoned men. To my mind, philanthropy does not do enough; it receives only such men as care to come, and who, after receiving the present advantage of the shelter of the Prisoners' Aid Society, disappear into the mob. Can they not be secured in a more permanent way, and prevented from returning to repeat the same process?

This subject of habitual drunkards and petty offenders is at present engaging the attention of a departmental committee,

under the presidency of Sir Charles Cameron, Bart., M.P., and it is hoped that the recommendations of that committee will be such that, by improved legislation, this class may be effectually restrained, and the public protected.

This brings me to the question of the creation of Labour Colonies. The longer I live and see what goes on around me, the more anxious I am that these means of rescue should be tried. There are so many (what I would call) competing modes of philanthropic effort, that I feel the public are sick of all this begging and crying out for money. The result is that new, and probably improved, means of dealing with the class now before us cannot get a chance because of the large claims of the old; and also because, I am inclined to think, that so much is being put "on the rates" now-a-days that ratepayers decline to subscribe in charity at all.

Labour colonies should be founded at once, and should be open to all who cannot get employment, but primarily to the discharged prisoners who cannot get work; and they should be supported and managed by the public, with representatives from the municipal, county, and poor-law authorities and officials—these bodies being empowered to afford financial aid if necessary. I prefer a mixed management like this, on which are represented the outside and charitably disposed ladies and gentlemen, whose influence for good can be seen in a variety of institutions connected with the city, while the public representatives would be an additional guarantee for careful and economic management.

Objections may be taken to the colony being primarily for discharged prisoners, but I hold that if we get rid of these men we solve the question of the unemployed. Doubtless there are many poor and aged labourers, unable to work, who swell the ranks of the unemployed; they also would naturally fall to be dealt with by the management of the colony and by the poor-law authorities, who would naturally be in close contact.

Indeed, with the poor-law authorities dealing with those who are unable to work, either outside or in a colony, while the labour colony receives all who are able yet cannot get work, and the active observation by the police of all begging, vagrancy, and drunkenness, I predict that the streets of our cities and towns would very soon be cleared of a class which is a disgrace to our civilisation and Christianity, and the honest unemployed would be enabled to find work of a more permanent character.

No doubt, the element of compulsion is present, but compulsion

is required now with infectious diseases and the insane, and why not with the beggar and his filthy rags, with the idle and drunken vagabond?

I cannot do better here than quote the following from the German penal code :—

"By the 361st section of the German penal code, amongst other provisions, it is enacted that 'he is punished with imprisonment'—

"(1) Who, after he has been put under police supervision, breaks through the restrictions under which he has been placed.

"(3) Who goes about as a 'tramp' (Landstreicher).

"(4) Who begs, or directs, or sends out children to beg, or fails to prevent persons from begging who are under his control and supervision, and belong to his household.

"(5) Who gives way to play, drink, or idleness, so that he falls into a state in which the help of outsiders (fremde Hülfe) has to be claimed, through the intervention of the authorities, for his maintenance, or the maintenance of those for whose support he is responsible.

"(7) Who, if he receives relief from public poor funds (Armenmitteln), refuses, out of dislike of work, to perform a task suitable to his powers, which is assigned to him by the authorities.

"(8) Who, after loss of lodging, which he has had up to the time, has not, in the interval permitted him by the proper authorities, procured for himself a lodging anywhere else, and cannot show that, notwithstanding the trouble he has taken, he has been unable to do so."

I would refer you to an exhaustive paper by Professor M'Cook, of Hartford, Conn., U.S., in the American *Forum* for August, 1893, where the professor, who has given more attention to the question of vagrancy than any man I know of, gives his solution of the tramp problem.

As a contribution to the question of the relation of German labour colonies to prisoners, I refer you to the "Report on Agencies and Methods for dealing with the Unemployed, 1893," page 277, which brings out the broad fact that three-fourths of the colonists admitted in the two years referred to had been imprisoned.

No reference has been made to the female unemployed, and the relation of the females to the unemployed in general, cannot be summarily set aside; but I feel that in the majority of cases the

enforced absence of the so-called bread-winner, or husband, is a blessing to the wife; and, necessarily, if he is an inmate of a labour colony, he will be the more amenable to advice, and the management of the colony will prepare him for a better mode of life on his discharge, in place of being the means of throwing his wife and children on the charity of the public. There are various other considerations which may be adduced to show that these colonies, in place of harbouring men from their wives and families, and being the resort of husbands deserting their wives, will be the means of reforming them, and tracing them when they so desert. Speaking as a poor-law officer, I think these colonies, conducted upon the same lines as those in Germany, will be a benefit to the wives and children, and will in a measure put a stop to frequent desertion by the husbands.

Up till now no forward step has been taken for the establishment of such colonies, purely and simply for the want of money and the support of the public, but the Charity Organisation Society of Glasgow has done a wise thing in starting a more modest undertaking, and what ought to become the feeder for such, in the form of a shelter, at 60 Kyle Street, somewhat upon the lines of the Berlin City Colony. I fear the very extensive proposal suggested by the reporters under the labour colony scheme, and the agricultural experts particularly, involving the outlay of about £20,000, is too large for an untried experiment in this country, and I am now strongly of opinion that an outlay of about £3,000 will enable any committee to give the experiment a fair trial. If any money is to be lost over an attempt to grapple with such an evil, £3,000 will be less missed than £20,000, and, besides, greater experience will be gained with a smaller number of men under more personal control and management.

VII.—"*Aluminium: Is it to be the Metal of the Future?*" By

A. H. Sexton, F.I.C., M.I.M.&M., Professor of Metallurgy, Glasgow and West of Scotland Technical College.

[Read before the Society, 9th January, 1895.]

It is hardly possible to over-estimate the important part which the metals have played in the evolution of civilisation; indeed, progress has been concurrent with, and to a large extent dependent on, the development of metallurgical industries.

In the earliest days of the period covered by more or less authentic history, men were acquainted with only six metals—namely, gold, silver, lead, copper, tin, and iron; and in the first half of our era mercury and zinc were discovered, bringing the number up to eight. Since then chemical research has added about fifty more to the list. Most of these are still chemical curiosities, but a few have found practical applications in the arts. Three—namely, platinum, nickel, and aluminium—have become of considerable importance, and others have been used to a less extent.

Of the new metals, aluminium is the only one which has attracted much public attention, and this on account of the important characters in which it differs from the metals in common use. It has now ceased to be a mere curiosity, and has taken its place in the work of the world; its chemical properties have been ascertained in many laboratories; its physical properties have been tested in many workshops; and improved methods of production have reduced the price to a point at which it can find many uses; and it may be of interest, therefore, to review the position which the metal is likely to take in the arts, and to see for what purposes it is likely to be more satisfactory than the metals at present in use. Very much has been written about this metal, and the most sanguine ideas have been expressed as to its uses. We have been told that we are passing from the age of steel into the age of aluminium, and that in the future—probably,

the near future—aluminium would replace other metals for constructive purposes; that, owing to its lightness, bridges could be built of it of enormously greater span than are at present possible; that ships could be made of about one-third their present weight, and thus of enormously increased speed; that we should ride about on bicycles weighing 5 or 6 lbs., if even flying machines had not been built of it, and so on. These speculations have, of course, not been made by persons acquainted with the properties of the metal, but rather by the lay press, ever on the look-out for something new, and ready to praise with a zeal untempered by knowledge. They, nevertheless, have done considerable harm by withdrawing attention from those purposes for which the metal can be satisfactorily used.

In the middle of the last century it was shown that alum when heated yields a white earth (Pott, 1746), and a little later (Margraff, 1754) that the same earth existed in clay. Early in this century, Davy, having isolated the metals of the alkalies by electrolysis, very naturally surmised that alumina might also contain a metal, and that the methods which had liberated the metals of soda and potash might liberate it also. He tried the experiment, but failed to obtain the metal. In 1824, Oersted obtained the metal by decomposing the chloride with potassium, but it was not till 1854 that Deville, by substituting sodium for potassium, obtained the metal in quantity, and he immediately set up the first works for its production. From that year, therefore, we must start the history of the economic uses of the metal. Shortly afterwards, Dick and Percy obtained the metal by decomposing cryolite by sodium, and about the same time Bunsen and Deville obtained it by electrolysis, using the fused chloride as electrolyte.

In trying to estimate the practical utility of a metal, account must be taken not only of the properties on which its usefulness will depend, but also of the price at which it can be produced. The price of a metal depends on various conditions—on the cost of the ore or raw material, on the cost of the processes of extraction, and on the scale on which operations can be carried on. A fall in price usually stimulates use; the increased demand enables production to be prosecuted on a larger scale, and thus causes a still further fall in price.

Aluminium is one of the most widely-distributed of the metals, and occurs in an enormous number of rocks and minerals. It is

an essential constituent of all clays—pure kaolin (china clay) containing about 21 per cent. of the metal; so that an ordinary brick, weighing 5 pounds, contains about 1 pound of aluminium. Raw materials containing aluminium are therefore very abundant, but, unfortunately, most of them are not suitable for any of the present methods of extraction, and, consequently, purer materials must be used. These, however, are by no means rare, and the cost of the metal is not due to the cost of the raw material. The materials from which the metal is obtained are (1) corundum or emery (Al_2O_3), the oxide of aluminium; (2) bauxite, a double oxide of iron and aluminium ($xAl_2O_3yFe_2O_3zH_2O$), with varying quantities of water, and containing about 30 per cent. of the metal—that used in this country being mainly obtained from the North of Ireland; (3) cryolite, a double fluoride of aluminium and sodium ($Al_2F_6 6NaF$), which is obtained from Greenland; and (4) alum ($K_2SO_4, Al_2(SO_4)_3 24H_2O$).

If the first or last named be used, the first step is to prepare from it pure alumina, to which the extracting processes can be applied. One difficulty in the present state of the metallurgy of aluminium is that there is no known method of refining the metal, and, as impurities in the ore would pass into the reduced metal, only very pure materials are available.

Until quite recently the only process in use was that of Deville, which, as already mentioned, was the first introduced. It was a very ingenious process, but, at the same time, was very complicated, and therefore very expensive. It was modified in various details, and was in use till within the last few years. This process consisted of four distinct operations:—

(1) Preparation of pure alumina from bauxite or alum (Webster's process).

(2) Conversion of the alumina into a double chloride of aluminium and sodium.

(3) Manufacture of sodium from sodium carbonate or caustic soda (Castner, Netto).

(4) Decomposition of the aluminium chloride by sodium.

Each of these processes was expensive in labour and materials, and as each pound of aluminium required for its production three pounds of sodium, and in the various stages about 550 pounds of coal, besides the other raw materials, the metal could never have been very cheap by this process. The Netto process, used for some time by the Alliance Aluminium Company at Newcastle,

was much simpler, and consisted in decomposing fused cryolite by sodium, which was made from caustic soda by a special process.

The only processes now in use are electric. In the Cowles process, the heat of a powerful electric arc is used to bring about the reduction of alumina by carbon in presence of another metal, usually copper, with which the reduced aluminium combines to produce a rich alloy. Pure aluminium is not obtained by this process, but, as a very large proportion of the aluminium is used for making alloys, it answers very well in this form. This process is used by the Cowles Company in America, and at Milton, Staffordshire.

The Heroult process, used by the Aluminium Industry Company of Neuhausen, the largest producers of the metal in the world, is an electrolytic process. Pure alumina is melted by the passage of a powerful electric current, and the current then decomposes the fused oxide. Aluminium separates at the cathode, and oxygen at the anode, which, being of carbon, is consumed, and the combustion helps to keep up the necessary temperature of the mass. This process is at present in use in Switzerland, and is about to be introduced into this country.

The Hall process is very similar, the electrolyte being a solution of alumina in fused cryolite; the cryolite acts as a solvent, and only the alumina is decomposed. This process is used at Pittsburg, and has been used at the works of the Magnesium Metal Company, near Manchester.

Both these processes are worked continuously till the anode is consumed. The power required is obtained from the cheapest of all sources—a natural head of water,—so that the cost is comparatively low, and the older chemical processes, unable to compete, have been abandoned.

The price of aluminium has fallen very much during the last few years. In 1856 it was £20 a pound, at which price it was, of course, only a chemical curiosity; in 1863 it had fallen to £2 10s., and was beginning to be used for special purposes; in 1883 it had fallen to 5s. 3d., about the lowest price at which it could be produced by the chemical processes. Now the price is about 1s. 9d., or less in large quantities, and this is probably about the lowest price at which it can be produced by the present processes, and at this price there should be a large demand.

Another improvement which has taken place is in the increased purity of the metal. In 1887 the purest metal in the market

contained about 95 per cent. of aluminium, now the best qualities contain 99·5 or more. This is of very great importance, because small quantities of impurities have a considerable effect on the properties of the metal.

The uses which have been proposed for the metal depend mainly on its three most striking properties—the colour, the lightness, and the power of resisting atmospheric and other corrosion.

As regards its colour, the metal is white, under some circumstances rivalling silver. There are many white metals, but most of them have a tinge of blue, which is decidedly unpleasing. The colour of aluminium varies somewhat with its purity and the way in which the surface has been treated. As a rule, the purer the metal the whiter it is, a small quantity of silicon especially inclining it to blueness. The metal takes a fine polish, but the polished surface has a bluish tinge, and the finest colour is seen on the matt or rough surface, especially if it has been cleaned by the action of very dilute hydrofluoric acid.

The lightness of the metal is one of its most important properties; certainly it is the one which has attracted most attention. It is not by any means the lightest of the metals, magnesium and the metals of the alkalies being lighter; but it is the lightest of the metals the other properties of which will allow them to be used for constructive purposes. On lifting an ingot or an article made of aluminium, it seems abnormally light; this appearance, however, is to a certain extent deceptive, and depends on the unconscious use of the imagination, and our general idea that the metals are heavy bodies. Seeing a metal ingot, we unconsciously expect it to be heavy, and, therefore, on being lifted, it seems even lighter than it really is.

The following table gives the relative weights of the common metals, and will serve for reference :—

	Water = 1.	Aluminium = 1
Platinum, ...	21·5	8·15
Gold, ...	19·3	7·31
Lead, ...	11·35	4·3
Silver, ...	10·5	3·98
Copper, ...	8·9	3·37
Wrought Iron, ...	7·8	2·95
Tin, ...	7·29	2·76
Zinc, ...	7·14	2·70
Aluminium, ...	2·64	1

It is easy to give numerical ratios, but it is not easy for the mind to form any real idea of their meaning. A graphic representation may make the matter clearer. Fig 1 represents a series of rods of different metals, all of the same diameter and of equal weight; and Fig. 2 represents a series of pieces of various metals, of the same thickness and the same weight.

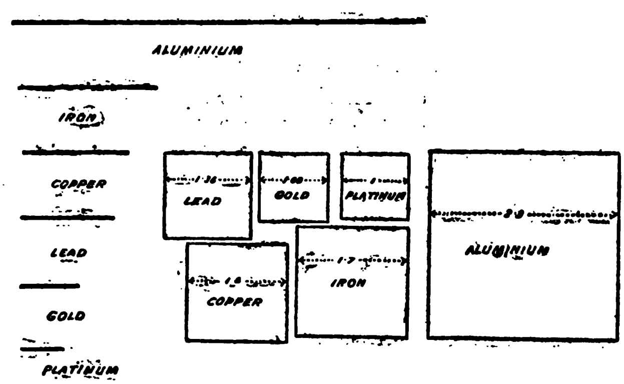

FIG. 1. FIG. 2.

It is not surprising that the great lightness of the metal should have attracted attention, and led to hopes that by its means many things might be done which had hitherto been impossible. But for most purposes lightness alone is of little importance; for structures and machines strength is of equal or greater moment; and in this aluminium is deficient. The tensile strength of cast aluminium is only about 6 tons, and of the worked metal 12 tons on the square inch, and thus, while it is about one-third the weight of mild steel, it is only about one-half the strength, so that, replacing one metal by the other would only lead to a slight decrease in weight, accompanied by a considerable increase in bulk. Therefore, even if price were not a consideration, there would be little real gain by the exchange. As the price of aluminium, however, is not likely ever to be reduced sufficiently low to bring it into serious rivalry with steel, it is not necessary to dwell on this part of the subject. For any purpose where lightness is required, and where strength is of less moment, the metal can be used satisfactorily. In Germany it is said to be used for military accoutrements. It is used for the mountings for photographic lenses and field-glasses with very great advantage. In instruments of this kind the glass weighs very

little, almost the whole of the weight being in the metal fittings; and as these by the use of aluminium can be reduced to about one-third, the saving in weight is very considerable. At present the price charged for aluminium fittings, in excess of that charged for brass, is ridiculously out of proportion to the extra cost of the metal, or of working it; but makers seem to think that it is fair that those who first take up an improvement should be made to pay fancy prices. Light boats have been built of the metal with considerable success. Alloyed with a little copper, to give it hardness, it has been used for shoes for race-horses, thus reducing the weight of the set of shoes by about 2 lbs.

It is very sonorous, and this, combined with its lightness, makes aluminium specially well fitted for bells and for wind instruments of all kinds.

The untarnishability of the metal in air is another important property. Most metals when heated in air become converted into oxides, and many of them burn brilliantly—as, for example, magnesium and zinc. Aluminium when melted, even at high temperatures, retains its brightness, but if it be very finely divided, and then projected into a flame, it burns with a bright flash, which is so rich in actinic power that it has been used for photographic purposes.

When metals are exposed to ordinary atmospheric conditions—that is to say, to moist air containing carbon dioxide,—all except gold, silver, and platinum (the noble metals) tarnish or rust, becoming covered with either a film of oxide, as in the case of iron, or carbonate, as in the case of lead. Aluminium resists these agents almost perfectly. On exposure to the air the surface dulls a little and becomes slightly bluer, owing to the formation of an excessively thin layer of oxide; this, however, acts as a protective coating, and the oxidation goes no further. The air of towns contains also various sulphur compounds which act on many metals, on silver especially, covering it with a layer of black sulphide, so that silver tarnishes very rapidly in ordinary town air. Aluminium is not acted on by these bodies, and therefore it will retain its colour under conditions in which silver would be rapidly blackened. It is, therefore, admirably suited for the manufacture of ornaments; it is sometimes used for making the so-called silver lace, as, being very ductile, it is easily drawn into very fine wire. This wire is at first not quite so white as silver, but it does not blacken as silver does.

For domestic use, for cooking utensils, and similar articles,

altogether other properties are required, and these aluminium possesses to a high degree. Cooking utensils are usually made of iron, either tinned or occasionally enamelled inside. This is a fairly good arrangement if the enamel does not chip off; while for purposes for which iron is unsuitable copper or brass pans are used. Aluminium is far preferable to any of these. It is not acted on by dilute acetic acid (vinegar), or by the fruit acids, all of which attack copper, forming green basic salts; neither is acted on by animal or vegetable juices, nor by infusions of vegetable,* such as tea, &c., nor by salt. The interior of vessels made of aluminium can therefore be kept quite clean and bright, and, even if it were slightly attacked, the compounds formed would be quite harmless. As a substitute for silver, it is far superior to electro-plated goods. These are always electro-plated over some copper, nickel, or other similar alloy, the coating of silver being excessively thin. When the silver is worn off, the metal underneath usually has a yellowish tinge, and it is almost always attacked by organic acids. All are familiar with the green deposit which forms on such articles if they are left for a short time in contact with organic matter. For such purposes, therefore, as pickle forks, fruit spoons, or fruit knives, aluminium is admirably suited.

There is one purpose for which it is far better than silver—that is, for egg spoons. Eggs contain a considerable quantity of sulphur compounds which rapidly blacken silver, and, to avoid this, the interior of egg spoons is usually gilded. As aluminium is not attacked, the gilding is not necessary. In use, articles of aluminium, such as spoons, darken and lose their lustre; it is, however, easily restored by polishing with jewellers' fine rouge or other plate powder.

There is one objection to the use of aluminium for household purposes, serious or not, according to the point of view of the individual; that is the action of alkalies. The metal is dissolved by strong caustic soda, with the evolution of hydrogen and the formation of solutions of alkaline aluminates. Carbonate of soda must, therefore, never be added to vegetables boiled in aluminium vessels. Weaker solutions, and solutions of the alkaline carbonates, and, therefore, of soaps with excess of alkali, attack the surface and blacken it, so that for cleaning aluminium articles, soda, or the alkaline soap powders and so-called dry soaps, must

* On long boiling of vegetable infusions containing salt the metal is attacked to a very slight extent.

not be used. A good soap has no action in the time which it need be in contact with the metal. The darkening is only superficial, or, in the case of polished goods, is readily removed by polishing.

Aluminium is very malleable, can be rolled into very thin sheets, and is infinitely preferable to tin or lead foil for packing articles of food, and in such a case as this, where the cost of the material is but a small fraction of the labour put upon it, the use of a more expensive material can be little disadvantage.

There are many other directions in which aluminium is used. It takes oxygen very readily from most oxides at high temperatures, and is, therefore, largely used in the refining of metals, such as copper. It is also used in steel-making for promoting soundness of castings. In the laboratory, it is also a valuable reducing agent. The alloys known as aluminium bronze and aluminium brass have remarkable properties, which render them of very great value in the constructive arts.

As to the working of aluminium, but little need be said. The metal casts readily and yields very fine castings; it can be hammered or rolled, stamped, or spun; indeed, anything that can be done with copper can be done with aluminium. There have been great difficulties in the way of satisfactory soldering, but these are said to have been now overcome.

Aluminium may be regarded as a very valuable addition to our meagre list of useful metals, and one of which increasing use will be made as time goes on, and as the inertia of the public is gradually overcome. It is always difficult to make changes. Aluminium will certainly not supersede iron and steel for constructive purposes on a large scale. It will, however, be largely used for lighter articles, where strength is not so important, and where lightness or resistance to corrosion will be valuable. It seems still expensive, but it must be remembered that, owing to its lightness, a pound will go about three times as far as the same weight of copper; so that with copper at, say, £48 a ton, bulk for bulk, the ratio of prices will be about 1 : 1.23—not at all a serious difference for articles of no great weight. It is likely to be very largely used for household purposes. It is, of course, enormously cheaper than silver; little, if any, dearer than nickel or German silver; and, therefore, it is likely to be largely used for ornamental purposes. We are not entering on an age of aluminium; but there is no doubt that the use of the metal is only in its infancy, and it has a very promising future before it.

VIII.—*An Old Glasgow Architect on Some Older Ones.* By THOMAS GILDARD, Honorary Member of the Glasgow Architectural Association.

[Read before the Architectural Section, 3rd December, 1894.]

THE apology for a "paper" bearing this title being read before this Society by me is, that I am now probably the Father of the Architectural profession in Glasgow. Mr. Burnet is my senior in years, and has been longer in practice, but he is now worthily crowning "a youth of labour by an age of ease," while my hands are still pretty busily engaged—the left with the T-square, and the right with the compasses and pencil.

Judgment is the faculty that is last in arriving at maturity. Whether my judgment has, like the fruit on the standard tree, been matured all round, or, like that trained against the wall, only upon one side, it has certainly had time to ripen. Memory is the faculty that first gives indication of decay. That which to a man in his prime seems a brilliant proof impression, may appear to the oldest inhabitant as a faded photograph, the general lineaments being confused and vague, and the particular features indistinct and shady.

In December, 1838, I was apprenticed for five years with Messrs. David & James Hamilton, whose office was at the head of Buchanan Street, on the site now occupied by the George Hotel. Mr. Hamilton was in about his seventieth year, and was a man of most impressive presence, frank and kindly in manner, with a bearing of ease and dignity. He was, to use a common expression, somewhat "aristocratic" in appearance, and in social intercourse was distinguished by much grace and courtesy. James, his son, had not much more than attained his majority. He was tall and remarkably handsome; his fine features had somewhat of an Italian cast, and his long glossy black hair was rolling in ringlets.

When I entered the office the late Mr. Rochead had been in it six months, a draughtsman, and the (now also) late Mr. Baird, a year or two.

As the house and office were together, the "lads," as we were called, were almost every morning favoured by a visit from Mrs. Hamilton, who took a seat, and had a kindly chat with us for half-an-hour or so. It seemed almost as if we were living "in family," and, although it is a long time since, there remains with me a pleasant impression of the homely, hearty kindness I experienced from all the Hamiltons under the old-fashioned arrangement of house and office together.

Mr. Hamilton had formed an excellent library, of not only great books on architecture, but of books illustrative of painting and sculpture. He had also many choice line engravings, and other things that might be expected in the house of a family all of inborn, and some of highly-cultivated taste. Mr. Hamilton was the recognised head of the profession, his position was unique, and, as his fame had gone beyond Glasgow, he had, I might almost say, frequent visits from men of eminence in the arts, bearing letters of introduction. I remember seeing Kemp, the architect of the Scott monument, and Mr. Hamilton taking him down stairs to see the office, and likewise, I have no doubt, that we "lads" might see him.

You know, I dare say, that Mr. Hamilton was architect of the Royal Exchange and Hamilton Palace. In both of those buildings, as in several others, he was fettered by the condition of retaining a portion of an existing building. In the Exchange the old Stirling Mansion (afterwards banking-office), is veneered within and without, and what is retained of the old palace is what was its front elevation, now doing service as its back. It seems strange that the Glasgow of little more than sixty years ago, the Glasgow that had the spirit and discernment to erect such a magnificent building as the Exchange, should have been so "penny wise and pound foolish" as to incorporate with it any of the petrified skeleton of a former structure. In both buildings the difficulty has been most successfully overcome—in the Exchange by the adaptation of the old walls, and in the palace by the reconciliation of the new front with the old; indeed, the taking down of the fine façade, now the back of Hamilton Palace, would have been a thing to be regretted. Of course the Exchange was finished before my time but the work of the palace was still being carried on, both Mr. Rochead and Mr. Baird having occasionally some detail of it upon their boards. These buildings, from their magnitude and importance, would otherwise have conferred a reputation upon any

architect, but in their quality they may be taken as specimens of Hamilton at his best.

The portico of the Exchange is grandly proportioned and admirably detailed, and where there is a variation from the example it is made with great judgment. The scale of the order upon the sides is different from that on the front, and I have heard it said, by those much more able to judge than myself, that the junction of the two is effected with much art. From its fine proportions the reading-room has been often the subject of praise, and the area-railing and the lamp-irons are seemingly among the first attempts in Glasgow to give an art character to such accessories. I may mention that in the "after-measurement" of the Exchange "the line" was "held" by our venerable Treasurer, Mr. Howatt. The portico of the palace is of the same high quality as is that of the Exchange, and the detail of the building throughout is bold and vigorous. Some of the graces of his art may have eluded him, but, at least, when in his zenith and in his later years, Mr. Hamilton's work was largely characterised by that easy power which "gave the world assurance of a man." Whatever other fault it may possess—the detail may sometimes lack purity, and sometimes refinement—it has never feebleness.

> "Void of weak fever and self-conscious cry,
> Truth, bold and pure in its own nakedness"—

it is singularly free from all meretricious artifice; defects are not sought to be diverted from or disguised by cunning of mere handicraft or costliness of material, nor is regard importuned by any undue obtrusion of special parts or "features." The architecture is as honest as is the masonry—stone being treated as stone, and not as wood or plaster.

While I was in the office, besides Hamilton Palace, there were being designed and executed Lennox Castle, the Western Club-house, and the British Linen Company, the Union, the Clydesdale, and the Western banking-offices, and such smaller works as Hutchesons' Hospital School, a Church at Ascog, Saint Fillan's Villa, near Largs, the Lodge at the Fir Park Necropolis, the completion of the Normal Seminary, and additions to Stonebyres and Camis-Eskan Mansions.

Lennox Castle is in the Norman style. In its composition are united breadth and picturesqueness, and, as it stands on a considerable height, these are seen to advantage, Mr. Hamilton, no doubt, knowing how to compose the building with the

landscape. The plan is excellent, both for convenience and vistas; indeed, the "Architectural Publication Society's Dictionary" considers it as one of Hamilton's best. I do not know if Mr. James participated in the designing of Lennox Castle, but he was considerably exercised as joint-architect of all the other buildings that I have mentioned, excepting, of course, Hamilton Palace and the Royal Exchange, which were too early for him to have had any share in.

The site of Saint Fillan's Villa is a knoll commanding two views of the Firth of Clyde, and, to embrace these, recourse was had to a peculiar plan, something like the letter A in outline, the entrance being in the lower side of the bridge, and the entrance-hall resolving itself into a triangle, with large semicircle on each side. The lodge of the Necropolis is of the same style, as is Lennox Castle, and the detail is very similar.

In its way the addition to Stonebyres House is very good, but it is scarcely of the same period as the original building. The old house is Scottish, and the addition is Jacobean; but in Mr. Hamilton's time architects were not so familiar with the niceties of some of the mediæval styles as they are now.

The little church at Ascog is beautifully situated on a promontory, and, as "the right thing in the right place," forms one of the most interesting objects in a singularly interesting landscape. It is exceedingly simple in design, seemingly modelled on some sort of the rural architecture of Italy. I think it is to be regretted that the roof is not covered with red tiles, instead of harsh blue slates.

I am not familiar with the addition to Camis-Eskan House, but, so far as I remember, it was something plain, as if it had been part of the original. In the addition Mr. Hamilton had, at least, the satisfaction of exercising his judgment, perhaps not so brilliant a faculty as is the imagination, but always entitled to, yea demanding, recognition.

After Mr. Hamilton's death, the Western Bank was considerably altered by Bryce of Edinburgh, and since the Company's bankruptcy it has been altered again, some vestiges, however, remaining that show the genius of each architect, and tell that once it was a public building. The Clydesdale Bank is on a minor key, and looks plain, perhaps even commonplace, compared with that which we see in the elevations of more recent banking-offices.*

* Several years ago the Clydesdale Bank removed to a palatial building in Saint Vincent Place, designed by Mr. Burnet.

Although not without blemishes in composition, and detail, such as two windows instead of three in the upper stories of the wings, and some questionable foliated ornament—which, indeed, was Rochead's—the Western Club-house enjoys a greater dignity than do most buildings in Glasgow, and this not because of its size—generally an impressive element—but of its breadth of treatment, repose, and that quiet unconscious power which is always favoured by the unspectacled critic. There is nothing petty about it. All is large and liberal, broad and massive, an outcome of a mind that had no room for littleness—playing with "bits," and toying with stones bedded in mortar as if they were gems set in gold. "And, to add greater honours to his age," this, although one of Hamilton's latest works—carried on, indeed, while in his last illness,—is wholly different in style from any of those in which he chiefly achieved his fame. In the Western Club-house, and a contemporary work, the British Linen Banking Company's office, there is a remarkably ready apprehension of the change that was coming over the spirit of architecture, the new and freer manner that has been ascribed to a succeeding generation.

In thirty years' time the Club-house became too small, and an addition was built from designs by Mr. Honeyman. This addition is a continuation along Saint Vincent Street, and much improves the proportion of this elevation, for, although the building is throughout characterised by greatness of manner, in the frontage towards Saint Vincent Street the windows are so tall and comparatively so close together, that the façade has perhaps as much of the vertical as the horizontal in its composition. Mr. Honeyman has judiciously carried along the lines of the original building, his principal innovation upon the genius of his example being a bay or oriel window upon the second floor. This gives interest to the elevation, and, although placed at an irregular interval, like to a discord in music, in nowise disturbs the general harmony of the design. But it is possible to "manage with disjointed skill the matter well the manner ill," and a bay-window resting upon a balcony (a parallelogram in plan, and extending lengthwise beyond it), the balcony carried by consoles over a three-light window, seems to be a somewhat illegitimate construction, both æsthetically and mechanically. For the three-light window, the consoles, and the balcony, there is warrant from the Buchanan Street elevation, but when

consoles have "a double debt to pay"—to carry besides a balcony a bay-window—they should surely be of a more powerful outline, and have a larger treatment. Mr. Honeyman has thought fit to vary them, and, having varied them at all, might have varied them more, and made them greater for their greater purpose. The endeavour apparently has been to continue the genius of the design, by carrying into the addition in Saint Vincent Street a prominent feature from the Buchanan Street elevation, and to compose with this a wholly new if not foreign element, and by this composition to subserve two purposes—to vary, by something distinctive, the fenestration on two floors, which would otherwise have been commonplace, and, on the two others, to derive from this a legitimate apology for a change of spacing of voids and solids, necessitated from the frontages of the old and the new buildings having to each other (for the design) no proportional relation. This want of proportional relation has also stood in the way of a continuously regular division of the panels, windows, and trusses (a study from Piranesi), which form the frieze, and of the blocks in the main cornice. An addition to the Western Club-house was not an inviting subject, and this not from the high reputation of the architect of the original building, or from his manner being so very different from that of the time in which Mr. Honeyman was engaged on it, but from the consideration that to do no more than continue the original design would be to render the whole façade commonplace, and that to do more might be to disturb the whole composition. Mr. Honeyman has done more without disturbing, and, in that "more," has added a new interest.*

The principal elevation of the Union Bank as designed by Mr. Hamilton was taken down some years ago, and another elevation has been put in its place by Mr. Burnet. The chief feature of Mr. Hamilton's design was a Roman-Doric frontispiece of six columns with pedestals, and balusters between them, forming a screen-wall. The frontispiece had a depth of about ten feet, in which access was had by the screen-wall between the extreme columns of each end being left open. This frontispiece is now part of the Royal Princess's Theatre, but the diameter of the columns being reduced to three-quarters, and they being veneered upon the walling, the effect, of course, is very different from what it was when they

* There is a perspective view of the Western Club-house in *The Art Journal* of October, 1889.

were entire, with a shadow-depth of ten feet behind them. Besides the alteration on the front towards Ingram Street by Mr. Burnet, there was the taking-down of the telling-room, which was towards Virginia Street, and the substitution of another from a plan by Mr. Salmon. The original telling-room had access from Virginia Street by a Roman-Doric colonnade of four columns. Between Mr. Burnet's façade and Mr. Salmon's telling-room, there is comparatively little left representative of David Hamilton.

While speaking of the Western Club-house, I incidentally mentioned the British Linen Company's Bank. There was in one of the sketch-drawings an idea to finish the circular corner with a dome, but this intention was departed from, in deference, I believe, to the dignity of the Exchange. I remember Mr Hamilton showing his sketch-design to Mr. Rhind of Edinburgh, the architect of that admirable work, the Commercial Bank in Gordon Street. Immediately after the British Linen Bank was completed, a lithograph drawing of it was published, showing statues on the pedestals of the balustrade that crowns the main cornice.

Hutchesons' Hospital School has, like the Union Bank, been so altered and added to that there is little of Mr. Hamilton's building to be seen. Originally, although not without some play of composition, it was comparatively plain, the trustees being either unable or unwilling to expend much money, or thinking that plainness in even such an important school was enough for its situation.

A considerable time intervened between the building of the wings of the Normal Seminary and the building of the centre part, with its square-columned porch and clock turret. The turret is well outlined, but I do not think that the connection of the later with the earlier work is, in some particulars, well managed—some of the leading features of the original not being carried along, whereby the composition is less integral than it might have been. I have little doubt that the cause of the Seminary not being erected all at once was the want of money, for Mr. Stow, the enlightened and zealous promoter of popular education, did not enjoy much public recognition of his doing the State some service. I have seen, as if Mr. Stow was the subject of Goldsmith's lines—

> "Even children followed with endearing wile,
> And pluck'd his gown to share the good man's smile."

It is not creditable to Glasgow that there is no public memorial

of a man who was such an advanced pioneer in the reform of education.

Saint Paul's Church in John Street is comparatively small, but perhaps few buildings by Hamilton are more characteristic of his manner.

A good example of Hamilton as a tenement architect is the Cleland Testimonial at the corner of Cathcart and Buchanan Streets.

Mr. Hamilton was essentially a Roman architect, and such buildings as the Royal Exchange and Hamilton Palace place him in that style in the very foremost rank among modern architects. They are of the best type of Roman—simple yet dignified in conception, powerful yet subservient in detail, and not overburthened or distracted by pompous and assertive ornament.

In Mr. Hamilton's time the Gothic revival had made little progress, and as his principal achievements had been in other styles, it is possible that he had little sympathy with it. Saint John's Church, off Gallowgate, is an example of his work in Gothic. Its detail is certainly not the most exemplary, but viewing it as Sir Walter Scott advised Melrose to be viewed, it is seen to be a composition of great dignity of proportion. Pictorially it is one of the grandest features in the civic scenery of the East-End, and seen from the Fir Park, it is an impressive object in even the general picture of Glasgow.

Mr. Hamilton was more successful in the Jacobean style. Dunlop house, finished shortly before I began my apprenticeship, is in that style, and was one of his favourite mansions. An addition to an old house is what was originally intended, Sir John Dunlop having some sentimental regard for what had been the ancestral home, but the addition's claims and charms advanced with steps, perhaps slow, but sure, and at last took possession of the old home with the exception of one solitary chamber.

In the Houses of Parliament competition Mr. Hamilton was awarded the third premium. The style which he adopted was the Elizabethan or Jacobean. In the Donaldson's Hospital competition Mr. Hamilton was one of three architects selected, the others being Gillespie-Grahame and Playfair. Mr. Playfair's design was chosen, and Mr. Hamilton's, I understand, received an honorarium of three hundred pounds. Mr. Hamilton's elevation was Ionic, the arrangement of parts being somewhat similar to that of the principal façade of Hamilton Palace.

A somewhat exhaustive list of Mr. Hamilton's works will be found under the article "David Hamilton" in the "Architectural Publication Society's Dictionary."

The office hours were from nine till seven, the hour between four and five being the interval for dinner. On Saturday the office closed at four. There was no gas in the office, and in the winter evenings we wrought by candle-light.

Two assistants of long before my time were James Gibson and John Thomson. The Hamilton family always spoke of James Gibson with affection for his kindly disposition, and with praise of his abilities. He died shortly after having begun business. John Thomson became architect of the Tennant town residence in West George Street (in which is shown much of the manner of his master), and of Elmbank Crescent, a range of buildings possessing many excellences well worthy of careful study.*

The Hamiltons' method of get-up or finish of drawings was somewhat different from that at present in practice. Both father and son were exceptional colourists, as also had been an older son, William (who had been dead many years before the time I am speaking of). Hence, as much as from it being the custom of the period, all sketch-elevations were highly coloured in Indian-ink, in sepia, or in a brilliant style after the manner of the famous architectural painter, Roberts. The drawings were not merely washed over, but all the shadows were carefully projected. The effects were produced by repeated coats of transparent colour; even the plans and sections of "working-drawings" always received two coats. I remember there was over the mantelpiece an elaborate perspective, by William Hamilton, of an Italian court or quadrangle, in which the shadows were almost absolutely black, nevertheless, they were so transparent that the most delicate mouldings and ornament beneath them were as visible, clear, and distinct as when the drawing-in pen had newly left them. The colouring of James Hamilton—who possessed remarkable abilities as an architect and draughtsman, as well as colourist—was less laboured, more sketchy, than that of his father and older brother, and often showed much depth and brilliance. The writing on the sketches and working drawings was invariably in a peculiar small back slope, and done with a crow pen, not the steel imitation, but cut from the quill of the wing of the veritable *cornix.* Full-size detail drawings were always inked in and coloured.

* Now almost wholly removed for railway improvement purposes.

It might be expected that David Hamilton left many interesting drawings, but a very large number, chiefly details, were burned when it was found that there was no room for them in the office, and a less honourable fate befell others that had been kept carefully in portfolios. These portfolios, containing drawings of the great Queen Street Theatre, the Royal Exchange, Hamilton Palace, churches, mansions, &c., and many of them of great beauty, by a misunderstanding, fell into the hands of an architect of no great professional repute, and now some years dead, and he ignominiously consigned them to an underground cellar, where they remained literally to rot.

The late John Mossman's father made a bust of David Hamilton; another, by Patric Park, is in the Corporation Galleries, alongside that of Glasgow's other great architect, Alexander Thomson; and his portrait was painted by Saxon and by Macnee. In the dining-room there was a fine portrait of the Duke of Hamilton who built the palace, testifying to friendship no less than to professional association; and I believe that Mr. Hamilton was also familiarly known to the Earl of Eglinton. This grand old architect knew how to deport himself in the society of dukes and earls.

A contemporary of Mr. Hamilton was Peter Nicholson, who is better known to us as the author of such standard books as "Treatise on Perspective and Isometrical Drawing," "The Architectural Dictionary," and "The Carpenter's Guide," than as a practising architect. For Glasgow he designed Carlton Place, and in this, to transpose the line of the poet, we find his work inspired by what his precepts taught. I know one of the houses, that of Mr. Robb, banker. Its plan is unique, and the dining-room and library are remarkably fine rooms, the former decorated by sculptured panels on the walls. It is claimed for Nicholson "that he was the first who discovered that Greek mouldings were the section of a cone, and he defied any person to prove that he ever derived any information from foreign works."

Another contemporary of David Hamilton was William Stark, of whom Sir Walter Scott said that "more genius died than is left behind among the collected universality of Scottish architects." He gave to Glasgow four public buildings, of varied character, and all of the highest excellence—the Jail, Saint George's Church, the Lunatic Asylum in Parliamentary Road (now offices of the City Parochial Board), and the late Hunterian Museum.

The Jail was one of the earliest endeavours in this country to

apply Greek architecture to our commonplace circumstances, and although, of necessity, it has windows, they in nowise detract from the broad and severe treatment, proper alike to the style and to the purpose of the building. The Doric portico, with its deep recess, is not only of great dignity in itself, but is in aptest harmony with the general composition. Unfortunately, by repeated alterations on the street level, the building is now sunk from its original platform. I have heard it said that Stark would have liked the composition to have been a superstructure upon a low stylobate. The steeple of Saint George's Church may, in beautiful and picturesque outline and fine play of light and shade, perhaps, vie with even the best of Wren's steeples. And yet there have been attempts made again and again, on one pretext or another, to have this beautiful steeple and the church removed, one being that they stood in the way of the public convenience, and another—adding insult to injury—that the valuable site might be occupied by a building for business. The traffic is not yet so great as to require their removal, and the greater the traffic becomes, they will be of the greater advantage—it being diverted, that going west taking the one side, and that going east taking the other. There was a proposal at one time to convert the church into municipal buildings. Mr. Low made a design in which he took down the church, but retained the steeple, piercing it on four sides, and utilising it as an alcove for a public statue or a fountain, or as a refuge from a shower, or a waiting-place.

At the time of its erection, the Lunatic Asylum was considered to be one of the best-planned in Europe. For external effect, its plan is exceedingly happy, an octagon, with wings branching from four of its faces, and this octagon resolving itself into a circle crowned by an oviform dome of great beauty of outline—the arrangement of octagon and wings affording opportunity for grand massive effects of light and shade. I can scarcely believe that the finial on the dome was the work of Stark. It is both bad and out of place. Of course, the exigencies of the different purpose have necessitated great alteration on Stark's original design, and I hesitate to say whether they have all been made with judgment.

The Hunterian Museum was a perfect model in Roman architecture, and, severely purged of its vulgarities, was an exquisite study of all the best qualities of the style. The portico

was Doric, and the general building, square in plan, was crowned by a dome of comparatively flat outline. But modern utility respects not beauty. *Utile et dulce* are divorced, and the Hunterian Museum, under the shadow of the University, had to yield to the stronger and more respected force of a railway station. And it seems within the fitness of things that the Juggernaut wheels of the steam-engine should have crushed out of existence one of the chief ornaments of that University which to the illustrious Watt had given encouragement and protection. I heard the late Mr. Mossman make a suggestion that the museum might be built as a shelter-house in the South-side Park, but whether or not this suggestion was put before the Parks Committee I know not.

Stark was likewise architect of the gallery front and the canopied pulpit that, until lately, were in Glasgow High Kirk. One of Stark's pupils was Playfair, of Edinburgh. Stark, it may be said, was not a Glasgow architect, but his grand contributions to our city are for this brief notice, I think, a sufficient apology.

John Herbertson had in early life been in the office of David Hamilton. While in business on his own account he was for many years architect to the Prison Board of Lanarkshire. In Saint Columba Church, Hope Street, he introduced somewhat of a novelty—the elevation of the part of the area beneath the gallery two or three feet above the general floor-level, access being had from a plat on the stair leading to the gallery. The effect is good, and those farthest from the pulpit benefit by the eye-line given by the greater elevation. John Carrick, John Baird, and Alexander Munro, were successively assistants in Mr. Herbertson's office, and James R. Napier, son of the eminent engineer and shipbuilder, and who became a Fellow of the Royal Society, learned in it architectural drawing.

My predecessor as an apprentice was Charles Wilson, but a few years elapsed between his giving up his drawing-board and my taking possession of it. He was a favourite pupil, and was in the office while Mr. Hamilton was engaged in much of his best work. He remained some years beyond the expiry of his apprenticeship, yet, when in business for himself, he was no follower of his master. If a chief element in Hamilton's genius was masculine vigour, Wilson's was characterised by feminine elegance. We have examples of this in such buildings as the Hall of the Faculty of Procurators, the High School (now in Elmbank Street)

and the Free Church College, with its church. In all these there is great refinement combined with delicacy and much charm of composition. I know few things more satisfactory in the way of an architectural prospect than the Faculty Hall as it may be seen from the south-west shortly before sunset. The building is certainly not without defects, such as coupled columns—a corruption which even the great name of Wren fails to honour,—and these columns engaged with the walls; but its general proportion, its harmony of parts, and its quiet easy elegance of manner, compensate in a great measure for violations that are perhaps only known to, and seen by, the old-fashioned critic. In the gallery of College Free Church there is an out-of-the-common arrangement. The gallery staircase does not lead, as is usual, to the level of the backmost seat, necessitating from this a descent to the level of the lowermost, but stops short at the level of the second lowermost, introducing to a passage which feeds the two lower seats, and whence arise steps to the higher. To this arrangement there is one objection. It defines a social distinction, and of this we have enough otherwise in churches professing the worship of the one Father.

In one of the works by Mr. Wilson there is shown the influence of his master. I refer to the gateway to the Southern Cemetery. The detail is almost exactly the same as that of Lennox Castle. He had not the training of a Gothic office, nevertheless he used Gothic with appreciative skill in several of the Disruption churches.

An early work was one of considerable importance, Gartnavel Asylum. In this he showed not only common sense but common honesty in not wasting money on useless details, useless as "a joy for ever" to the unfortunate inmates, and useless to a building that by the general public could be seen only from a distance. After maturing the plan, he gave his chief attention to the composition, the grouping, the massing, the sky-line, and the light and shade resulting from the alternation of projection and recession. The elegant range of residences which the West-End Park bears as a coronet, and the great granite staircase leading to it, are evidences of the delicate yet healthy spirit which in Wilson's work is a principal characteristic. Mr. Wilson was an architect whose works can always be looked on with pleasure by the ordinary beholder, and with profit by the intelligent student. For some time he had as partner his brother John, but John's must have been "a back seat" in the business. Charles's name

appears twice in the "Architectural Publication Society's Dictionary—in its own place, and in the article "David Hamilton."

As I have said, Mr. Rochead had been about six months in Mr. Hamilton's office when I entered it, leaving it immediately after, having taken the first premium (one of fifty pounds) in a competition for a church in Ireland. He was an Edinburgh man, a pupil of David Bryce, and was intimately acquainted with all the detail of George Heriot's Hospital. He was eminently a picturesque architect, although Queen Margaret College and Buckingham Terrace attest his mastery of the best phase of Italian. His Saint John's Free Church, George Street, was an early experiment in Gothic, and enjoyed much popular admiration, but in those days of the Gothic revival we were thankful for small things. His Park Church, however, shows him in that style in the fulness of his power; while in the later Italian, as chastened as was latterly his apprentice-master, he was in that variety of the style more directly descended from the Roman, exceedingly bold and vigorous, as in the United Presbyterian Church at the corner of John and Cochrane Streets. Its stylobate story is rich and massive, and the contour of its mouldings, as of those of the whole structure, show the firm and easy pencil of a master. The Ionic colonnade which it carries is, however, not so satisfactory. The intercolumniation is filled in with glass, and it was possibly expected that by this, as it is transparent, the columns would have been emphasised with a certain semblance of relief. We can easily imagine what would have been the effect of somewhat of a recess welcoming the deep soft shadows of the summer setting sun. A similar boldness of conception and vigour of execution characterise, with "jutty, frieze, and coigne of vantage," the magnificent building at the corner of Nelson Street and Trongate. It is the same with the Wallace Monument and many of his mansions. Were we to judge only by the Unitarian Chapel, we would say that the Greek graces seemed to keep themselves aloof, but for a picture-gallery and a school of art in Greek Doric which he designed for George Square, they happily waited upon him in all their native purity and dignity. These buildings, with an open colonnade abutting upon the Scott Monument, and rising no higher than its pedestal, would have been a great ornament to the Square, and would have in nowise interfered with the thoroughfares designed by Mr. Carrick. In the dual competition for the India Office and the War Office, he occupied the same position as

did Sir George Gilbert Scott—he gaining the third premium for the one and Sir George for the other. He was a man of indomitable energy; in the more picturesque styles he had a most fertile fancy, and, if not much of a colourist, was a splendid draughtsman; in ornament, bold, vigorous, and sweeping. Conscious of power, which he could readily wield by his facile draughtsmanship, his high ambition would have undertaken such works as Westminster Palace, the London Law Courts—even Saint Paul's Cathedral. It might almost be said of him, as Dr. Johnson said of Milton, "his was a genius that could cut a Colossus from a rock, but could not carve beads out of cherry-stones." His name has secured a place in Irving's "Dictionary of Eminent Scots," and in the "Dictionary of the Architectural Publication Society." Our recent president, Mr. Douglas, was one of his pupils.

The architect, in some respect, of perhaps next importance to Mr. Hamilton was Mr. Baird,* a gentleman who enjoyed a large practice, and a very large measure of the esteem of his fellow-citizens. Although his practice was extensive, somehow he has left to us few important public buildings. One of his best was one of his earliest, the Wellington Street United Presbyterian Church. This building is a square box with a portico at one end of it, a form of church with which, in our own day, we are not wholly unfamiliar, a simple enough composition, yet how rarely successful. In this church are to be seen several of the best qualities of architecture—proportion and harmony, a sense of breadth and repose in the general effect, and a sympathetic feeling with this in all the details. The portico is part of the structure, is not stuck on and as little stuck up to it. The church has, within the past few years, been metamorphosed by Mr. Burnet into a music-hall, and whatever he may have done with the interior, he has with the exterior had the good sense to let well alone. One of Mr. Baird's latest works was that extensive range, the Macdonald warehouses, with elevations towards South Hanover and Ingram Streets, and George Square. These elevations are treated with, for Mr. Baird, singular freedom, a freedom, however, to which there is no sacrifice of law or dignity. One of Mr. Baird's chief employers was Sir James Campbell, and

* There were two architects in Glasgow of the name of John Baird, their periods of practice over-lapping—the above-mentioned and he who was assistant with Mr. Hamilton.

for him he designed the stately range of buildings in Buchanan Street, immediately north of the Arcade. Sir James employed him also on his firm's warehouse in Ingram Street, but, when he wished the style to be old Scottish, Mr. Baird recommended that the elevations should be by Mr. Billings. The designing of one very important building was entrusted to Mr. Baird, but he had not the satisfaction of seeing it executed. In 1846 he was employed to design the new College, intended at that time to be built at Woodlands. The plans were approved, and Parliamentary powers obtained for carrying them into execution, but for some reason, unknown to me, this scheme was abandoned. The style was Jacobean, doubtless in compliment to the old structure in High Street.

Alexander Thomson was for some time Mr. Baird's principal assistant, and during this time there were in the designs that issued from the office certain characteristics that did not appear either before or after, the presumption being that much of the unwonted manner emanated from the aspiring genius of the then young ardent "Greek." Mr. Baird, being a man of not only upright character and sound judgment, but of also great experience in all that related to house property, was extensively employed in valuations and arbitrations; and he was held in high estimation. Like his several brothers he was a large and well-built man, and he had a presence as of one that ought to be in authority. In Maclehose's "Century of eminent Glasgow Men of the past thirty years" there is a brief memoir of Mr. Baird by the facile pen of Mr. Honeyman. Latterly Mr. Baird assumed as partner Mr. James Thomson, our late president.

One of Mr. Baird's brothers, Anthony Baird, was a short time in business as an architect, but he relinquished this profession for that of accountant, in which he attained a high position. There is a tenement by him on west side of Warwick Street, a short distance beyond Norfolk Street. Its treatment is broad, somewhat peculiar, and along the frontage a considerable use is made of cast-iron balcony.

John Bryce was an architect who, if not great, was at least clever. He had seemingly been educated in a school which, however it appeals to our sentimentality, does not imbue us with any sense of orderly stateliness—the Elizabethan or Jacobean. But if the style was bad, Bryce made the best of it, to prove which we may visit the Necropolis, and look at the elaborate screen at the

east end of "the Bridge of Sighs," and the M'Gavin Monument. While there we may look also at that sequestered little nook, the Jews' burial-place, where he has been seized by the *genius loci*, and on which in an architecture affecting no particular style, and not much of it, he has left a peculiar interest appealing not only to the intellect but to the heart. One of Bryce's largest works is the Reformatory in Duke Street. John Carrick was a pupil of Bryce.

Of men of culture, no less than of "the rude forefathers of the hamlet" of Stoke-Pogis, it may be sometimes said "their lot forbade." Robert Foote was a man of considerable natural ability, and of a refined taste: he had enjoyed the benefaction of travel, and was otherwise a favourite of fortune, but during many years he was afflicted by a disease which wholly incapacitated him from exercising his advantages. His works are necessarily few, but there is one which must command the regard of all who can appreciate restful dignity of composition in union with severe simplicity of detail, the warehouse-building at corner of Buchanan Street and Royal Exchange Place. In Mr. Foote's town house, situated in Blythswood Square, there was, I have been told, some very fine plaster work. "Greek" Thomson began his apprenticeship with Mr. Foote, and remained in his office until Mr. Foote, because of his illness, retired, when he went to Mr. Baird. In a cellar Mr. Foote had a large collection of plaster casts, from which his apprentice made drawings, the shadows being thrown by the flickering flame of a tallow candle. It is likely that it was to Mr. Foote that young Thomson was indebted for his enthusiasm in the style with which his name is now so closely associated. Mr. Foote's country house was The Peel, near Busby, and Thomson, while in the office, was there frequently a guest from Saturday afternoon till Monday. The disease by which Mr. Foote was literally laid low was an affection of the spine. He got made for himself a carriage into which was brought a hydro-bed, and in this he made considerable excursions. He lived latterly at Helensburgh, and that he might be a regular church-goer, provision was made in the church for the ingress and egress of his little vehicle. From Helensburgh he at least once drove to Luss, where his hydro-bed was put into a row-boat, from which by the arrangement of mirrors he enjoyed the scenery of Loch Lomond. What I have said of Mr. Foote I learned mostly from Mr. Thomson, who always spoke of him with almost a filial regard and affection.

The architect of the Custom-house with its façade of Greek Doric columns was Taylor, of Taylor & Cressy, authors of a standard work on Rome.

James Collie did not do much important work as architect, although the Doric portico of the railway station in Bridge Street —until it was spoiled by being "curtail'd of its fair proportion"— gives evidence of his cultivated taste; but he rendered good service to the profession by his delineations of Linlithgow Palace, and by his larger and more elaborate work of views, plans, elevations, sections, and details of Glasgow Cathedral. Till Collie's time little had been done towards the illustration of Gothic remains in Scotland, and when the "Cathedral" appeared it favourably revealed both the spirit and the execution of Mr. Collie's purpose.

Clarke & Bell—*par nobile fratrum*—came from Edinburgh as the successful competitors in the design for the County Buildings and the Merchants' House—two buildings, "yet a union in partition," for one of the conditions of the competition was that, while there was to be a general harmony of the one building with the other, each was to have its individuality. By the Ionic portico in Wilson Street and the Corinthian colonnade in Hutcheson Street, the unbroken entablature connecting them, and several minor features, this condition has been admirably complied with. It is to be regretted that an inimical fate in some measure prevented the façade on the south of the Merchants' House being continued on the north. However, as it is, this group of buildings is enough to keep Clarke & Bell in the foremost rank of Scottish architects. Looking at the perspective view which embraces Wilson Street on the south and Hutcheson Street on the west, I know few Greek compositions that surpass it. The southmost section of the Brunswick Street elevation is itself worthy to confer a reputation. Within the County Buildings and the Merchants' House there is some delightful detail of plaster work. In one of the staircases a descent of Mercury from a dome is effected with remarkable cleverness.

About this time Brown & Carrick were in business. They did some church and a considerable amount of tenement work, and were, by a competition, the architects of the Corn Exchange—afterwards altered by Messrs. Barclay & Watt. Circumstances occurring favourable to the respective interests of both partners, the copartnery continued only a few years. The office of Superintendent of Streets becoming vacant by the resignation of Mr.

Hume, Mr. Carrick became a candidate, and was appointed; and, not long afterwards, Mr. Brown succeeded to a small landed estate in the neighbourhood of Edinburgh. In the interval Mr. Brown designed Renfield Street United Presbyterian Church, a building that, at the time, received considerable criticism—chiefly on account of what was thought to be extravagance. Mr. Brown was architect also of Messrs. Orr & Sons' building at corner of Union and Gordon Streets, a building remarkable for its dignified composition, fine proportion, and beautiful detail.

Mr. Carrick became in time, as well as Superintendent of Streets, Master of Works and City Architect. It is only in this last-mentioned office that we have to do with him. His opportunities and powers were necessarily circummured by the boundaries of his situation. He was "*City* Architect," and his work was among police-offices for the criminal, hospitals for the diseased, lodging-houses for the poor, baths, wash-houses, and what have been called "artisans' dwelling-houses." Besides triumphal arches and other decorations for royal and other processions, the new front to the City Hall was to this comparatively humble kind of work perhaps the principal exception. But, in however humble the work, Mr. Carrick never forgot that he had been bred *an architect.* The police-office in Tobago Street shows a mastery of Italian design and detail, while several of the lodging-houses are dignified by the broad treatment of the composition. Of his plans it is enough to say that not only his lodging-houses have been closely copied in London; that his artisans' dwelling-houses, besides having been studied by London authorities, have had "honourable mention" bestowed upon them in America; that his baths and wash-houses have been copied by the burgh surveyor of a metropolitan city; and that Belvidere Hospital has received the highest commendation of travelled experts; but that also several of the plans received a "Diploma," or certificate of merit, from the London Health Exhibition.

Besides being a city official, Mr. Carrick was, after the death of Mr. Herbertson, Consulting Architect to the Prison Board of Lanarkshire. It may be mentioned that, while a young man, he "held the line" to Kemp when taking measurements of the Cathedral. Mr. Brown would, I think, be a pupil of one of the Bryces—John, of Glasgow, or David, of Edinburgh. The only time I saw him was while he was in the company of a Bryce pupil, Mr. Rochead, when on a visit to another, Mr. Carrick. One of

Brown & Carrick's apprentices was James Thomson, architect of the Royalty Theatre, and of good reputation as a planner of poorhouses.

A Mr. Taylor flourished in the period under review, but of whose works I know little. Two of them, however, are worthy of notice—Royal Crescent in Sauchiehall Street, and Clarendon Place at corner of Great Western and New City Roads. The crescent has at intervals one feature which at the time was a novelty—a semi-circular projecting window. The centre of the range is marked by a pediment over pilasters, the prevailing effect of which is flatness and weakness where might have been expected emphasis and strength. Clarendon Place is situated at a sharp angle, and there is a corresponding one opposite at the corner of Saint George's and New City Roads. Upon a stylobate embracing the height of the street story, there is at the Great Western corner a four-column portico, the order being a study from the Tower of the Winds; and there was an intention at one time to build on the opposite corner a counterpart, the effect of which would have been similar to that of Waterloo Place, Edinburgh. But the time has passed; the status of property in the locality may have changed, or there may have been other causes which prevented the stone-and-lime realisation of the happily-conceived idea of the architect or his employer.

Alexander Munro was the successful competitor when designs were invited for the Allan Glen School, at the corner of Cathedral and North Hanover Streets. An addition has been made to this school, and in a different style, by Mr. Forrest Salmon. Mr. Munro was likewise architect of a dissenting church in Blythswood Holm, and of many dwelling-house tenements. One of his pupils, or assistants, has become distinguished as a Gothic architect, an archæologist, a sanitarian, and a social reformer—Mr. Honeyman.

During a few years a James Wylson practised in Glasgow. He ultimately went to London, into, I think, the office of Sir Charles Barry. While here he did a warehouse in Buchanan Street, to the south of the Arcade, recently destroyed by fire, a church in the East-end, some warehouse work in Queen Street for Samuel R. & T. Brown (now occupied by Arthur & Coy.), and some "model" dwelling-houses for the first Lord Provost Lumsden. All his works showed a certain mannerism, but it was that of a man who could think for himself.

William Spence, who had been in the office of John Bryce, had an extensive practice in both town and country. His principal work in Glasgow was the Theatre Royal, Dunlop Street, designed for the famous actor and manager, John Henry Alexander. This theatre possessed many excellences. In the first place, it was eminently a comfortable house, one in which it was possible to see and hear from all parts. It had a magnificent stage; and the proscenium, and, indeed, the spectatorium throughout, was ornamented in a manner not only highly elaborate, but also highly characteristic of a theatre. The proscenium was composed of pilasters with entablatures, whence sprang an elliptical soffit. Between the adjacent pilasters was a door, over which was a "box" with balcony, and the soffit was divided into panels, wherein were sculptured subjects associated with the drama, music, &c. The proscenium throughout was rich in detail—in work in relief, as well as in gilding and painting. In the centre of the ceiling was a flat dome, divided into nine panels, in which were painted representations of the Muses. In the spectatorium were three tiers, and as these were placed with as little interval as possible between, the effect was not only rich, but comfortable-looking. The front of the lowest tier was ornamented by scenes from Shakespeare, the one immediately above by scenes from Scott, and the uppermost by appropriate conventional ornament. Externally the building expressed its purpose. The architecture was picturesque in composition, and ornate in detail, and, besides figures of Thalia and Melpomene in niches, there were statues on pedestals of Shakespeare, Garrick, and Mr. Alexander himself. The "elevation" of the last provoked a clever satirical lithograph.

Mr. Spence was architect of another theatre ("The City"), built on Glasgow Green for Anderson, "the Wizard of the North." Its tiers possessed the advantages of good acoustics and points of sight, but, as there was considerable distance between them, the general effect was one of chilly space. They were better to be seen from than looked at. A specimen of Mr. Spence's work of another kind is a Titanic engine factory at the corner of King and Dale Streets (Randolph, Elder, & Co.'s). Had the great gateway been lintelled instead of arched we would here have had something of the spirit of the old Egyptic. Hugh Barclay, co-architect, with his brother David, of Greenock Municipal Buildings, was a pupil of Mr. Spence.

The Palladian building on the west side of Miller Street, and with three sides of a quadrangle to the street, is by Mr. Kirkland. The design is ambitious, but the detail lacks refinement.

A firm in practice at the time of which I speak was Scott, Steven, & Gale, and, besides architecture, it professed civil engineering and land surveying. Of Mr. Gale, or his works, I never knew any particulars, and I think I may assume that he was the engineer and surveyor of the firm. I have heard of works of Mr. Scott apart from those of the firm, from which it may be inferred that he was at one time in business for himself as an individual, and I have heard the same of works of Mr. Steven. Judging by buildings that have been pointed out to me, Mr. Scott seems to have been a ripe architect, whether of much originality or not, certainly of much culture. A building by him in Buchanan Street, nearly opposite the Arcade, and since destroyed by fire, was quiet, yet dignified in composition, and elegant in detail, and, although by no means obtrusive, was seen to be the work of a man who thoroughly knew what he had to do. In Renfield Street, where the City of Glasgow Assurance Company's Office now stands, there was St. Mary's Episcopal Church in the Tudor style. It was of great merit, seemingly all the greater because built when the Gothic was, with us, not much beyond its infancy. When, by the kindness of a member of the Institute, I was one in an excursion to Bothwell, I was told that the addition to the old church was by Mr. Scott. This also shows that, in Gothic, he must have been amongst the most advanced, and yet the name or the work of this able architect is now seldom mentioned.

Mr. Steven was an architect of great promise, as may be judged from such works as Saint Jude's Church and the Mortuary Chapel of Sighthill Cemetery. The church is not altogether homogeneous, and, in some respects, is not well composed or well proportioned, but how noble the doorpiece, how grand in its own proportion, and how exquisitely detailed; how original the central and dominant feature on which it is superimposed, and how fine the conception of the manner of panelling the rustic walling of the return towards the east. It is these several excellences, alike original and powerful, that make us regret that there should be such blemishes as the great acroteria on the corners, the too small circular temple, which is the crowning feature, and the long, badly-proportioned windows of the wings. Saint Jude's Church early taught us the elasticity of Greek architecture. The mortuary

chapel is also Greek, and if those disturbers of the peace, the urns on the apices of the respective pediments, were away, the little building would seem to be perfect. The works of Mr. Steven are too few to place him prominently among the greater Glasgow architects, but they indicate that, with a longer life and greater opportunities, he would, with head and heart, have taken a high position in inventiveness and earnestness. He was highly gifted, and he exercised his gifts as if he felt that he was responsible for them.

John Baird, my early friend in the office of David Hamilton, after having for some time been in business as an individual, in 1849 entered into copartnery with his brother-in-law, "Greek" Thomson.* To quote the Architectural Publication Society's Dictionary (article "Alexander Thomson"), "During their partnership they jointly carried on many works in Glasgow and the surrounding country, as Knockderry and Craigrownie Castles; the Italian Villa; several marine residences on the shores of Loch Long, Langbank, and Innellan, on the Firth of Clyde, Rosneath and Garelochside, the Caledonia Road United Presbyterian Church, in Glasgow, and others." Mr. Baird was an ardent local antiquary, and on such works as this on which I am at present engaged he was the highest authority.

On "Greek" Thomson I spoke at considerable length in session 1887-8.

History has immortalised "single-speech Hamilton," and by a single poem some authors have achieved and merit a universal recognition. And some architects have had entrusted to them the designing of an important work, but who nevertheless have failed to build with it for themselves even "a local" reputation "and a name." George Murray was the architect of the City Hall, but beyond this I know nothing of him professionally except that, as was customary in his time with some architects, he had evening classes in which he taught drawing to clerks of works and foremen wrights and masons. The City Hall, being built over part of the Bazaar, and not having a street frontage, makes no pretention to architecture as a fine art in its elevations, their chief feature being the great lintels carrying the hall over that much which it covers of the area of the bazaar. Those were the days before daring things were ventured by cast iron, malleable iron,

* They married grand-daughters of Peter Nicholson.

or steel; and those stone lintels, to this day so admirably serving their purpose, attest not only the skill of the architect, but likewise the excellent workmanship of James Govan, the builder. An ordinary tenement in Candleriggs was altered so as to give access by a passage and staircase, which I fear would scarcely comply with present legal requirements. The hall within possesses several excellences: it has abundance of daylight, and Madame Titiens and Mr. Dickens spoke to Mr. Carrick favourably of its acoustics.

Of late years there has been expressed some dissatisfaction with the height, the "why" whereof is not as "plain as way to parish church," but raising the ceiling might raise also the sound. The ceiling, with its disposition and depth of panelling, has an almost classic severity. The decoration of the wall surface depends upon the painter. It was first in the hands of D. R. Hay, who painted it Sicilian marble, filling the space between the windows with arabesques in lapis-lazuli. In each panel of the ceiling was a piece of polygonal patch work, the colour and arrangement of which brought too vividly to remembrance the chequered motley of a harlequin. The proportion of the windows had long been an eyesore to Mr. Carrick, and when he had an opportunity he overcame it by placing casement windows in front almost flush with the wall, and which, by being narrower and "finished" with architrave, frieze, and cornice, have an appearance of greater height, also dignity, as the "finishing" hitherto had been a mere corner-bead. These casements have also a utilitarian purpose, the space between them and the outer windows being sufficient to allow of an ingenious mode of ventilation, and, as they are glazed in a low-tone colour, they serve as a "blind" screening from the spectatorium the chilling, cheerless lookout of a dark winter sky. In the semicircular heads of the casements are the armorial-bearings of, besides the Nation, the City, &c., the University, the Trades' House, Hutchesons' Hospital, and other local institutions. Originally the platform was on the south side, but it was removed to its present position, the east end, by the earlier John Baird, to whom the hall is also indebted for its present roof, a masterpiece of carpentry.

The present frontispiece towards Candleriggs is by Mr. Carrick, and, in my judgment, is well conceived for its purpose—dignified as well as correct in its composition, and pure without being effeminate in its detail. One of our oldest and most experienced

architects, once said to me, speaking of this elevation, "Mr. Carrick had a grand grip of it." It may be fairly questioned whether a public hall, especially one of such capacity as the City Hall, Glasgow, should be up a stair, but there be need no question as to the manner in which Mr. Carrick by his large entrance-hall, grand staircase, and long and wide crush-room, readily communicating with the hall of the bazaar, also other "vomitories," as the ancient Romans called them, provided for the safety and convenience of the public. The ingeniously-designed communication between the old and the new staircase is due to the skill of my friend and colleague, Mr. MacBean.

A James Watt, who died in Glasgow in 1832, was architect of various public buildings—of which, however, I know nothing,—a member of the Philosophical Society, and member and treasurer of the Dilletante Society, when this was founded. My friend, Mr. Baird, was in his early professional life in the employment of a Mr. Watt, but whether or not it was this gentleman I do not know.

There was a Mr. Fisher, with whom Mr. Baird was employed some time, who did much excellent tenement work on which he bestowed very careful detail.

About the time of the Free Church Disruption, Mr. Black and Mr. Salmon, each of whom had been separately in business, entered into copartnery. During the partnership they designed Saint Matthew's and Saint Mark's Free Churches, Glasgow; the Parish Church, Ardrossan; Irvine Free Church; a large warehouse near the head of the west side of Miller Street, and much general work. Before the partnership was entered into, Mr. Black had been architect of the buildings fronting Royal Exchange Square on north and south, and returning into Queen Street; also of other large and important warehouses; the City of Glasgow Bank, Virginia Street (taken down some years ago); Knox Church, Surrey Street (not yet finished); Hafton House, Dunoon, &c. After the partnership was dissolved, Mr. Salmon renovated the interior of Paisley Abbey, and to its exterior added a porch, and the restoration of a transept gable. He also designed Middle Free Church, Paisley; the Mechanics' Institution, Bath Street; the Victoria Free Church, Glasgow; the British Linen Company's Banking-office, Greenock, and several smaller churches, villas, &c. He likewise laid out for feuing the considerable estates of Dennistoun and Plantation. Mr. Salmon latterly assumed as partners his son and Mr. Ritchie, one of his principal assistants. In the time of this triumvirate

there were in progress, or being finished, the Deaf and Dumb Institution, Bluevale Church, and the British Linen Banking Company's branch office in Eglinton Street; also Middle Free Church, Greenock; and Woodilee Asylum, Lenzie.

Robert Reid had been asked, "as a gentleman of acknowledged ability," to engage in the competition for being architect of the Jail. A Robert Reed was architect of Saint George's Church, Edinburgh.

Thomas Burns' name is chiefly associated with the designing of several of the *quoad sacra* churches built shortly before the Disruption. Perhaps Mr. Burns' principal work is the Free Church Normal School, Cowcaddens. An addition was made to this building some years ago from a design by Messrs. Douglas & Stevenson.

On the 30th of April, 1824 (this is not "fifty," but seventy years ago) the foundation stone of the first building in London Street was laid with great masonic ceremonial. The London Street architect was John Weir, and although the date is anterior to the half-century imposed upon me, there is, perhaps, some excuse for rescuing an almost forgotten name, more especially as the London Street buildings were considered, when new from his hand, to be worthy of a stipulation "that the style of buildings is not to be altered without the consent of the Commissioners, whom failing, of the Town Council." Mr. Weir's elevations showed an excellence in design of tenements to which the Glasgow folk had doubtless hitherto been unaccustomed.

About fifty years ago the National Bank competition engaged the attention of several of the local leading architects. The design chosen was that of Gibson & Macdougall, London.

In 1855 twelve gentlemen, most of whom were architects, opened an Exhibition of Architecture and its Accessories in Bath Street. The exhibition was wealthy in its display, but in its financial result a miserable failure.

Some of the Edinburgh architects contemporaneous with, at least, David Hamilton, were Hamilton, Playfair, Elliot, Gillespie-Grahame, Rhind, Bryce, and Kemp. Hamilton was architect of that masterpiece in Greek art, the High School, also of the Burns Monument, and of the Burns Monument, Alloway, both of Greek architecture. Playfair designed a grand Greek building, the Royal Institution, and the Quadrangle of the University, no less excellent, in Roman. Elliot was architect of Waterloo Place, with its bridge, remarkable above for its beautiful screen, and below for its magnificent span; also of that singularly picturesque castellated

pile Calton Jail—as seen from the railway platform at the Post Office, a composition worthy of the genius of Turner. Glasgow is indebted to Elliot's son for that charming composition and admirably detailed work, the Royal Bank, with its accompanying arches. The Greeks knew the arch, although they did not employ it; but if they had used it, they would likely have applied it in the way adopted by Elliot. George Bell, of Clarke & Bell, was in the younger Elliot's office a pupil and assistant. Gillespie-Grahame was architect of the Assembly Hall, and of Saint Andrew's Roman Catholic Chapel, Glasgow, a building so much in advance of the Gothic of the time that when it was completed it was "the observed of all observers." Rhind was architect of the Commercial Bank, also of the Commercial Bank, Glasgow, and of the Glasgow Scott Monument. Bryce, like his brother John, of Glasgow, had been reared in the Elizabethan or Jacobean style, but he latterly escaped it, and did some work in Italian, the detail of which in purity and delicacy is perhaps equal to that of Barry. The offices of the Scottish Widows' Fund on the west side of Saint Andrew's Square, testify to this. The British Linen Company Bank, on the east side, and the prominently-placed Bank of Scotland in the old town, are both as beautifully detailed, but the former has its entablature broken over each column, and the other is deformed by broken pediments and by other contributions to, at least, the picturesque. Bryce also excelled in Gothic and Old Scottish, in which he was as vigorous as in Italian he was elegant. Rochead and Clarke, of Clarke & Bell, were pupils. Kemp, as everyone knows, was architect of the Scott Monument.

In these brief notices I have trusted to my memory and observation, and, in a few instances, have been indebted to information received from one or two friends. In my opinions my judgment may have been at fault, but in all that I have said I have been actuated by honesty of purpose.

I have bestowed more space upon David Hamilton than upon any of the other architects, and this for two reasons: in the first place, he was my apprentice-master; and, secondly, notwithstanding the position which he occupied, I am not aware of anything hitherto having been written of him, except the newspaper notices at the time of his death and the article in the Architectural Publication Society's Dictionary. Borrowing from Byron—

> "Illustrious Hamilton, hard would be his lot—
> His 'prentice mentioned and himself forgot."

IX.—EDUCATION AND AGRICULTURE: *A Discussion of the Bearings of the Technical Education Movement on our Greatest Industry.* By JAMES HENDRICK, B.Sc. (Lond.), F.I.C., F.C.S., Lecturer on Agricultural Chemistry, Glasgow and West of Scotland Technical College; late of the Royal Agricultural College, Cirencester.

[Read before the Society, 20th February, 1895.]

THE modern movement in favour of popular Technical Education is of comparatively recent growth. Isolated institutions have been carrying on work of this kind, in a more or less partial manner, for a long time. For instance, the Andersonian College, now incorporated in the Glasgow and West of Scotland Technical College, has been doing work of this nature for nearly a century. It was not, however, till quite recently, and then only under pressure from without, that general and popular interest was aroused in the question. The movement was already simmering about 1868, in which year a Select Committee of the House of Commons was appointed to inquire into the question; but it is only in the last five years, only since this decade commenced, indeed, that any real attempt has been made to meet the demand for instruction which shall place the masses of our people on an equal footing with their competitors over the seas. Meantime, we have given these competitors a long start, of which they are endeavouring to make the most.

Those who have intelligently watched the growth of this movement, with some knowledge of what has already been done in other civilised countries, must often have had their national pride humiliated by the insular ignorance and prejudice of their countrymen. One would almost have thought that no other nation had already experimented in this direction—such a capacity has this practical people exhibited for not knowing what to do, or how to do it. Proud of the fact that, hitherto, our most successful ventures in this and in every other field have been carried out by private and local enterprise, we quite lost sight of the fact that successful private enterprise presupposes a strong directing central force, generally a single person.

The funds set apart to supply technical education, originally obtained merely by a Parliamentary accident, were shoved into the reluctant hands of infant authorities, who, generally, had not the least idea what to do with them, and who, with a recommendation to apply them to technical education, were left quite without any central authority to which to look for guidance. We were so anxious to maintain our boasted individualism that we forgot that order, method, and a strong central control proceeding from those with knowledge of, and enthusiasm for, the movement in hand are needed, at any rate until things are organised and started. So we created a sort of educational chaos, with all sorts of overlapping and interfering authorities. Then we run off and cry that technical education is an expensive and useless fraud.

Even to-day it is difficult to persuade people of the absolute necessity of all that is included under the rather misleading term "technical education." We have not yet got a grip of the really urgent national importance of this question, and it is only in a misty way that we realise what has brought this movement upon us with such a rush.

The conditions of industry are not what they were. Try to realise how the advances of knowledge and science have revolutionised commerce and manufacture, and altered the whole of the conditions of the problem of successful industry. The commercial aptitude of our people, our energy and thrift, our long freedom from the harrying of war, our comparative enlightenment and education, enabled us, guarded by our bulwark of waters, and rejoicing in a plentiful supply of mineral wealth, to attain an almost unquestioned position in the world of commerce and manufacture. To such a position have we attained with our immense accumulated capital of prestige and experience, as well as of material, that we have come to have a contempt for the foreigner and his rivalry. In popular opinion all foreign goods are regarded, as a matter of course, as inferior and shoddy. But the world is changing, and the force which is changing it is knowledge. If we do not place our people on an equal footing with the foreigner as regards knowledge, all our other superior qualifications, and all our natural advantages, will avail us nothing, we shall come to live on our capital—some say we are already doing so—till we awake too late, and find it spent. So surely as a modernised and scientific Japan is advancing steadily and systematically into the vitals of her huge old-world

rival, so surely will the people who are sparing no pains or expense in their own education carve away our huge accumulations of advantage. But so great is still our insular contempt for the foreigner and for his rivalry, that, as has been well remarked, one of the most difficult things we have to do is to persuade this people that one Britisher is not equal to three foreigners; and, secondly, that he is not equal to two foreigners; and, finally, and hardest of all, that, with his present education, he is not equal to one foreigner. This seems to be a hard saying, but in too many cases it is only too true. It is not only that both from across the Atlantic and from across the German Ocean formidable rivals are keenly competing with us in our own markets, but whole branches of manufacture have already left our shores to take up their abode in a more educated atmosphere.

Lest this should be considered the mere vapouring of a scientist, let me quote you the opinion of a local magistrate. All bailies are supposed to be *practical* men, are they not? Bailie Cluckie, speaking recently concerning technical education and sugar-refining in Greenock, said—"If our refiners had pursued this policy"—that is to say, the policy of educating his workmen adopted by the "wily Teuton"—"or had technical education been adopted in this town a quarter of a century earlier, sugar-refining would not be now the decaying industry that it is; for instead of a few wealthy refiners who are satisfied with the 'what-was-good-enough-for-my-father-was-good-enough-for-me' policy, there would have arisen a younger school, who would have had their way to make, and who would have consequently been contented to work for less profit, and, to secure business, have adopted methods which would have prevented the foreigners from undermining our sugar trade; and instead of this trade languishing, it would be flourishing, and our good town would have been still entitled to be called 'Sugaropolis.'"

I cannot help quoting another opinion, taking this time from the "other side of the hedge." Professor Ostwald, one of the greatest thinkers among German *savans*, in a recent address to German electricians, while referring to the interesting fact that the manufacture of coal-tar products had forsaken Britain to be welcomed in Germany, said—"Here we have the remarkable situation that that country of all the world, in which industry has flourished longest, relegates the most important and profitable part of one of her manufactures to a foreign country. The reason

is of the plainest: England *cannot* undertake the conversion of its raw material into the finished product." This great thinker then goes on to point out that the reason for this is that the "would-be practical Englishman" does not believe in education, while the thoughtful Teuton does. I might multiply illustrations and quotations. But, you will say, what has all this to do with agriculture? I hope to show you that it is applicable in a special and pre-eminent degree to agriculture, the oldest and most fundamental, and the most important of all industries.

If the conditions of production and distribution have become more complex and difficult in other industries, they have done so to a quite equal degree in agriculture. If foreign competition is pressing our textile manufacturers hard, and producing depression in our metal industries, it is bearing not less hardly on a depressed agriculture. Nor can we afford to pass over agriculture as an unimportant industry which may be neglected. Agriculture is more important than iron, or cotton, or alkali. It employs more labourers, it feeds more mouths, it creates more wealth than any of these. Even in this great manufacturing and commercial country, where agriculture is relatively but a small fraction of our whole industry, compared with the great fraction which it forms of the whole industry of the world—even here, I say, agriculture is more important than any other single industry. If we take it on a population basis, the census returns of 1891 show that there are far more individuals directly employed in agriculture than in any other single kind of industry. The textile manufactures, including cotton, linen, wool, lace, silk, hemp, carpets, hosiery, straw plait, leather and skins, and other smaller allied industries, occupy a very large number of people, but they have to take a place second to farming; and they come a very long way second. So minerals and mining, in all their branches, are large employers of labour, but nothing like such large employers as the farm.

It must be remembered, too, that besides those who are classed in census returns as the agricultural population, there are a very large number of persons interested in various ways in agriculture who will be benefited by agricultural education just as much as those directly employed on the farm. Indeed, the statistics of agricultural classes show that landowners, teachers, the mercantile classes interested in agricultural produce, intending emigrants, often sons of professional or mercantile men, and various other

classes interested indirectly in agriculture, form a very large proportion of the pupils. And it must be conceded that this education is as useful and, indeed, necessary to these persons as to those directly engaged in farming.

Again, let us measure the importance of agriculture by looking at its annual production of material. Here I depend largely upon the Board of Agriculture Returns for the United Kingdom. These do not value the produce raised annually, as that would be well-nigh impossible, but merely give acreages. There are nearly 50 million acres in cultivation in the United Kingdom, besides over 12 million acres more classed as rough moorland and mountain pasturage, and some 3 million acres of woodland. For a rough calculation of the average produce per acre, I do not think it will be excessive to take £8 per acre as the total value of the produce raised annually on each of the 20¼ million acres of arable land, and £4 10s. per acre as the total annual value of the produce of each of the 27¾ million acres of pasture. This will give us a total of 287 million pounds annually. If we allow a little for the rough land and for the woodland, it will bring the total value of the produce raised annually by agriculture in the United Kingdom to about 300 million pounds sterling. As a comparison with this, take our total annual imports, which are valued at rather over 400 million pounds per annum, or our annual exports, which are worth about 300 million pounds per annum. We see, then, that agriculture deals with a bulk of material, comparable not with any single trade or manufacture, but with the whole mass of our export or import trade.

But perhaps I am preaching repentance to the converted in spending so much time over the importance of agriculture. We are, in this great world of commercial and manufacturing sinners, so taken up with coal, or iron, or cloth, or machinery, that the "*puir farmer*" is apt to be looked down upon as an unimportant outsider. Commerce and manufactures are so much in evidence, have their importance so concentrated into a few golden acres, that we cannot see past them to the vastness of agriculture spread out thin over scores of millions of acres. It is still very true that, as Liebig wrote long ago, "there is no profession which can be compared in importance with that of agriculture. On it depend the welfare and development of the whole human species, the riches of states, and all commerce. There is no profession in which the application of correct principles is productive of more

beneficial effects, or is of greater and more decided influence." Try as it will, our modern industrialism cannot get away from agriculture. All our science cannot teach us how to do without agriculture. We may look down on Hodge, but we cannot do without him : he is fundamental and all-important. The agricultural question—and that includes the question of agricultural education—is not a matter for the rural districts only, it is a matter affecting the deepest interests of the whole community.

It will be needless for me at this time of day to argue the necessity for what is called technical education. We all admit it. All we lack is conviction enough to carry our beliefs into practice. We admit its usefulness, and straightway go forth and neglect it, or haggle about the price which it costs. But, perhaps, in a country where rural teachers are required to know all sorts of sciences, but not the scientific principles of agriculture, and where agricultural teaching is the last thing which "My Lords" encourage in rural schools, it may be necessary for me to point out the special need which agriculture has for special teaching. All our railways, post offices, telegraphs, and telephones have not succeeded in giving the agriculturist the advantages enjoyed by his city brethren. He is spread out too thin. He cannot share in the educational benefits enjoyed by those in centres of population. His facilities for grasping and becoming familiar with new ideas, for keeping up with the progress of the world, are far fewer than those of men who are constantly rubbing together in the busy centres of life. Agriculture, as it is the most ancient, is the most conservative and slow-moving of industries—and rightly so. All experience has shown the folly of men making so-called advances on raw half-knowledge, misnamed scientific. But that is only the more reason why special facilities are needed to spread justly and moderately such knowledge as has been gained—such knowledge as our rivals are learning to use with such deadly advantage.

Into the questions of how well other civilised nations appreciate the advantages of agricultural education, and of the price which they are willing to pay for it, I do not intend to enter at any length here. That subject has already been dealt with again and again. This Society had the advantage of hearing a paper on this very subject a few years ago by Mr. (now Dr.) C. M. Aikman.*

* "Agricultural Education in this Country and Abroad, with special reference to Germany." By C. M. Aikman, M.A., B.Sc., F.R.S.E. Read before this Society, 6th February, 1889.

Dr. Aikman's paper was read almost exactly six years ago. At that time we had just awakened to the fact that the inferior education of our people was one of the great factors telling against us in our competition with the world. We were being told from various quarters that, while we had been living on our reputation, the German, the Frenchman, the American, our own colonies, and even that latest claimant to the position of a great civilised nation, the Japanese, had been educating their people agriculturally and otherwise. We have done much, it is true, during these six years to develop our own agricultural education, but we do not yet realise how far we are still behind, and how much there is still to do, if we are to range ourselves at all alongside other civilised peoples. Professor James Long, the well-known dairying authority, says:*—"We have now only to hope that we shall not be left behind Norway and Sweden, although we can scarcely hope to be placed upon a level with Germany and Italy, as regards the extent of even dairy education."

Here I hold in my hand an official pamphlet of over 130 pages issued by our Board of Agriculture, entitled "Report on the Distribution of Grants for Agricultural Education in Great Britain in the financial year 1893-94." Surely we are doing something now for agricultural education to call for this lengthy report, detailing the large sums spent by a generous Government for the enlightenment of agriculture? Yes. The report lays out in great detail how this extravagant Board lavishes the exact sum of £8,000 in support of agricultural education and research. Its most munificent grants are of £800 a-piece to one Welsh and two English colleges. The largest grant to Scotland is one of £600 to the institution with which I have the honour to be connected, the Glasgow and West of Scotland Technical College. I wonder if the fact that one Welsh college receives £800 and another £700, while a Scotch college doing exactly similar work in quite as important an agricultural centre receives £600, has any connection with the fact that certain Welsh members of the House of Commons have made themselves very much in evidence in supporting the claims of the Principality? We are yet waiting for the Scotch members to begin to weary out this extravagant Department by their importunity. Still, while there is only £8,000 to give, it is difficult for

* "Education in Dairy Farming and Dairying in Europe and America." By Professor James Long. *Transactions of the Highland and Agricultural Society of Scotland*, 4th series, vol. xx., p. 3.

the Board to increase their grants much. £8,000! Why, France spends more than this on the upkeep of one college alone, the Institut National Agronomique in Paris; and Germany is said to spend nearly double this amount in supporting the Agricultural High School in Berlin. Nor is it only on such great central institutions that these Governments—and these are but samples of what all other civilised nations are doing—spend large sums of money. All branches of agricultural education, from the highest to the lowest, are justly proportioned together, and duly supported. Agricultural research and experiment, too, are not forgotten. The splendid experimental research stations, which are found systematically distributed over nearly every other country in Europe, as well as over the United States, are maintained largely by Government subsidies. The little kingdom of Würtemberg, which is about the size of a large British county, spends more on its own account (and quite independently of the imperial expenditure) on agricultural education than the Board of Agriculture of the wealthiest country in the world. Why, the getting up and printing of our report about the spending of the grant must take up quite an appreciable part of the total sum.

In Germany the higher agricultural education is not usually given in a separate college, but in an institute attached to, and forming a distinct faculty of, a university. This very wise and economical plan has been taken up and largely followed at home also, where several of our great colleges have lately started agricultural departments. In this way the agricultural department is enabled to share in the general teaching of the university or college in many subjects which are just the same for agricultural students as for students of other faculties.

The foreign agricultural schools and stations with which I am best acquainted are those of Leipzig and Halle, in Germany. In both of these the agricultural institute is attached to the university. I cannot better illustrate the completeness of the teaching which we have to compete against than by giving a short account of how agricultural science is taught in Leipzig. The programme of university lectures of the agricultural department [a copy of which was exhibited to the Society] is perfectly bewildering at first sight. Work begins at 7 o'clock in the morning in summer, and continues till 7 in the evening. In winter it begins at 8 o'clock, and leaves off at 8. There are sometimes as many as four and even five lectures taking place at once, and three is a very common number,

There is also work constantly going on in various laboratories; there is practical dairy work; and there are forestry and other practical class excursions to instructive places in the vicinity. The same professor, too, never lectures more than twice in one day, and more often he lectures only once. The programme of instruction seems really too full. It would be impossible for any one man to benefit by all the work done here. No doubt the practical Briton would say the thing is carried to ridiculous and wasteful excess. But not too fast, my friend. This has all been considered by the careful Teuton, who is not given to wasteful extravagance. This curriculum is intended not only to meet the needs of every possible class of farmer and agriculturist, but also to provide for the training of all sorts of specialists connected with agriculture, and to enable the merchant and the manufacturer whose businesses are connected with agriculture to receive any enlightenment they may need on those parts of the subject which interest them. In Germany the university comes very near to the mercantile and manufacturing classes, and keeps in very close and practical touch with them. So here we have the higher teaching not only for the farmer, agent, or landowner, but also for the manure and grain merchant, the produce broker, and all the many other city people connected with the farming interest. Here we have also the training ground for the agricultural lawyer, agricultural chemist, agricultural botanist, bacteriologist, and all the other specialists connected with agriculture. And it is abroad that we have to send our men to be trained for these professions, if we want them properly trained.

There are nine professors in Leipzig giving courses of lectures on subjects intended solely for agricultural students. These include courses on practical agriculture and dairying, agricultural chemistry (on which subject two professors, an ordinary and an extraordinary one, give courses), agricultural botany, forestry, veterinary science, agricultural mechanics and engineering, agricultural bacteriology, and agricultural book-keeping. This might seem fairly complete, but it is not nearly all. There are, besides these, 24 professors and lecturers giving courses useful to agricultural students, and attended by these, along with students of such other faculties as science, law, or medicine. In this list we have lectures on general and physical chemistry, physics, mechanics, zoology, geology, microscopy, physiology, mineralogy, agricultural geography, agricultural law, the Darwinian theory,

various branches of history which touch on agriculture, such as history of the land and its laws, history of the peasants, history of national economy and finance, &c.; lectures on national economy, trade, commerce, and finance, on colonial expansion, on labour and the poor, on socialism, and communism, &c. Then there are an agricultural laboratory, an agricultural chemical laboratory, an experimental field, one of the most perfectly equipped working dairies that I have ever seen, a physiological laboratory, a botanical laboratory, a veterinary hospital, all open to the students for practical work. To complete the list, I should not leave out the fact that the official programme also gives the names of a riding master, a fighting master, and a dancing master. Now this is not a special or extraordinary example of a great German agricultural school. It is not the great high school in Berlin, attached to Berlin University, but only a provincial institute attached to a provincial university. Leipzig itself is a city only about half as big as Glasgow.

Only some twenty-five miles from Leipzig is the manufacturing and university town of Halle. In it we have what I consider the greatest agricultural school in the world. Greatest, not in having the biggest Government grant, for Berlin comes far before it in that respect, but in its prestige, in the great number of agricultural students whom it attracts from all parts of the world—a number which makes the agricultural department one of the largest faculties in the university,—and in the wonderful equipment of some of its departments. It is well to see Leipzig before Halle. After one has seen the wonders of Halle, one is apt to think even Leipzig "small beer." In Halle they have the agricultural lecture-room fitted with a stage on to which animals can be brought before the students during lecture. The professor illustrates his remarks on breed characteristics, not from diagrams and lantern slides, but from a good specimen of the animal itself. They have plenty of beasts, too. I cannot call their collection anything less than an agricultural zoological garden. Cattle are there of all breeds, from a great shorthorn bull to a Kerry cow, and from the big Dutch or Swiss dairy cow to the little humped cattle of India. Other classes of stock are on a similar scale. There is a large experimental farm attached to the university, worked entirely under the direction of the professors for the instruction of the students.

The teaching in these institutes, too, is as complete and

thorough as their equipment—too complete, perhaps, for British taste. A friend remarked to me, after we had listened to a lecture on the history of the development of the churn, delivered to his dairy class by a professor who is a very distinguished dairy authority, "Our people in Scotland would never stand that sort of lecturing. We dare not try it. It is not practical enough." But the same professor was "practical enough" a week or so later, when he lectured on placing butter on the London market. He handed round his class samples of various kinds of packing-cases and packing materials, and gave them estimates of their cost; he gave them hints how to cater for the English taste and catch the English market; and, finally, he gave them estimates of cost of transport and handling, showing how much these would add to the cost of the butter per 100 kilos. I never heard, even in this country, a more practical lecture.

Quite outside and independent of the universities, both Leipzig and Halle are supplied with agricultural research and control stations. Both these stations are large and complete institutions, and both receive large support from the Government. The Leipzig station, situated at Möchern, in the suburbs of the city, analyses some 3,000 commercial samples annually for farmers, besides carrying on some very important agricultural researches. The station gets a direct imperial subsidy, and a subsidy from the provincial Government, besides fees for the analyses, partly paid by Government through the agricultural societies, and partly by the farmers themselves. From these different sources the station receives support amounting to over £3,000 per annum. Similarly, the still larger station at Halle does annually about 7,000 commercial analyses, and receives annually (chiefly from Government subsidies, either direct, or at second-hand through the farmers' societies) about £3,500 per annum.

Here, then, covering a district not so large, not so wealthy as, and with an agricultural interest not more important than, that of the Lowlands of Scotland, we have two great university institutes for agriculture and two great research stations. It will be a long time before we can hope to rival such work. Are we going to wait till we feel the terrible pressure of a few more turns of the competitive screw before we even realise the need of it?

Such work cannot pay in itself. Neither the educational institutes nor the research stations can by any process known to

man be made to pay dividends, except in the lives of their students. The Germans are persuaded that if, by spending a million on teaching and encouraging agriculture, they can increase its prosperity even one per cent., they will have a profit to the community of hundreds per cent. on the transaction, such is the greatness of the agricultural turnover. Our mathematical and logical perceptions are not yet sufficiently advanced to enable us to clearly grasp that simple fact.

These details refer merely to what is being done for the highest class of agricultural education. The other classes are equally well looked after. For further details as to intermediate schools, lower and special schools, forestry schools, and travelling lecturers, I can only refer you to Dr. Aikman's paper already mentioned.

Prior to the present decade, very little had been done in Great Britain for agricultural education, especially in its lower branches. Private enterprise had done something for the higher branches in the foundation of such colleges as those of Cirencester and Downton, and the Government had contributed its mite by assisting to support the Chair of Agriculture in the University of Edinburgh, and by founding a Chair of Agriculture at South Kensington. Private munificence and enthusiasm, too, had founded the great research station at Rothamsted, and the agricultural societies had done something. Elementary and secondary agricultural education was practically non-existent. In Ireland things were rather different. In that country there has been for a considerable number of years a fairly efficient scheme both of elementary and of higher agricultural education. For some of our colonies, also, much has been done. For instance, in 1884 a Select Committee of the House of Commons inquired into Canadian agriculture, and, as a result, in 1886 the "Experimental Farm System Act" was passed, and now Canada is pretty well supplied both with agricultural education and with research stations. These, however, were very much needed, and were not supplied a moment too soon, if Canada was not to be left hopelessly behind by the United States, which lavishes almost incredible endowments on her agricultural colleges and experiment stations.

The agricultural education of Great Britain itself was most exhaustively gone into by the Royal Commission of 1881-84, which inquired into the whole question of technical education. Agriculture occupied a special section of the Report of this Commission, and the almost complete neglect in this country of elementary and

secondary education was specially pointed out. But Royal Commissions are said to be a means of putting off time, and it was not till 1889 that the Technical Education Act was passed. Even then, as no funds were provided for administering it, matters were not much further forward. However, a windfall soon came. In 1890 Mr. Goschen's Budget provided a special fund, raised by an extra tax on spirits and beer, intended to provide pensions for policemen and to compensate publicans. Public opinion objected to publicans being compensated. But the money had to be used somehow, so it was shoved on to county councils and local authorities, who were not enjoined, but merely recommended, to use it for technical education. At once the land was full of schemes for utilising this money—schemes big and schemes little, wise schemes and foolish schemes, schemes by those who knew something about the question, and still more by those who knew nothing;—and the world was treated to the edifying spectacle of our practical methods of wasting money.

The whole sum raised by Mr. Goschen's tax has, on the average, amounted to £1,350,000 per annum. Of this, 80 per cent. goes to England and Wales, 11 per cent. comes to Scotland, and 9 per cent. goes to Ireland. I presume the Scotch members of Parliament are quite able to look after the interests of their country. I must confess, however, despite my faith in the wisdom of our legislators, that I cannot feel satisfied with the method which has been adopted for the distribution of this grant. It may be all right and fair, but it is a little difficult to comprehend. On a population basis, Scotland, at first sight, seems to get just about her right share. But the case of Ireland shows that the distribution is not made on a population basis. On the basis of her liquor consumption, according to a recent article in the *Contemporary Review*,* Scotland should get no less than 25 per cent., and Ireland 15 per cent. But it is not till we come to examine how much of the grant is made applicable to technical education in the two countries that we find how great the disparity really is. In England, £300,000 are set aside for police pensions, leaving nearly £800,000 available for technical education. In Scotland, £40,000 go to provide police pensions, £40,000 to supply free elementary education in schools, and £15,000 to supply salaries for county medical

* "The Work of the Beer Money." By John Rae. *Contemporary Review*, October, 1894.

officers of health, leaving only £53,000 for the whole of Scotland to apply to technical education. This is not more than a single first-class English county receives. On the basis of population, Lanarkshire alone, if treated at the same rate as England, should receive £30,000, and the whole south-west of Scotland district should receive over £60,000. While the population of Scotland is about one-seventh that of England and Wales, the grant received by Scotland for technical education is only about one-fifteenth that received by the "predominant partner." Each individual in Scotland, though he pays far more largely to the revenue from which the grant is supplied, receives from Government to aid in his technical education rather less than one-half of what each Englishman or Welshman receives. But there is worse still to follow. Scotland, which sometimes modestly claims to be the brains and backbone of Great Britain, far from turning her paltry one talent to the best use, is not even putting it to usury, but is pilfering from it to benefit her pocket. England, though at first she seemed in a dilemma to know what to do with the two talents thrust upon her, is now settling steadily down to work, and adding to what she has received. Every year, as she gains confidence and experience, the more she applies herself to make her work thorough.

According to the latest (1894) official returns concerning the money which is being spent in Great Britain in promoting technical education, there are in Scotland, where the enthusiasm for education and enlightenment is supposed to be greatest, 122 burghs and police burghs which are applying *the whole* of their grant to the relief of rates. In England there is only one borough—the County Borough of Preston—of which the same can be said. In Scotland, 23 out of 33 county councils are applying the whole of their grant to technical education; in England, 41 out of 49 are doing so. In Scotland, where so many of the authorities are misappropriating their grant for the relief of rates, not one is raising a rate, under the Technical Instruction Acts, to add to their grant. In England, which is already applying practically the whole of her grant to the purpose intended, the councils of ten county boroughs are, in addition, either raising a rate or making a grant out of the rates in aid of technical instruction. Wales is setting the best example of all. Every one of the Welsh authorities (16 in number) is applying the whole of its grant to technical education,

and the councils of six counties and county boroughs are, in addition, levying a rate or making grants out of the rates, under the Technical Instruction Acts. Wales, with a population not nearly so great as that of the West of Scotland, is spending more on technical education than the whole of Scotland. A great many English and Welsh towns are spending large sums of money on new technical schools and on their fittings. For instance, Manchester, a town comparable to Glasgow, has acquired a site worth £100,000, and has just voted over £140,000 for buildings for a technical school. There are, in all, some 200 organised technical schools now at work, and a large number more in course of construction.

The sum which the authorities now have it in their power to spend on technical education is very large, and should be quite adequate to meet all demands for some time to come, if they will only use it. Mr. Mather, M.P., recently estimated that England and Wales have power to apply funds amounting to £1,800,000 to this purpose. Of this £780,000 is derived, from the Residue Grant, often called the "Beer Money," received under the Local Taxation, Customs and Excise Act; £664,500 from the penny rate on the whole rateable value of the country, which they have the power of raising under the Technical Instruction Acts; and £355,000 from grants under the Science and Art Department. To all this must, of course, be added much private and voluntary aid which has been granted to different schools and institutions of a technical character. These private funds also amount to a very large sum. There is, then, a sum of about £2,000,000 available annually for technical education in England and Wales. Of course, the authorities are not yet by any means using their full powers; but the movement is growing rapidly, and year by year more money is being allocated as things are getting into proper working order.

In Ireland, where there are no county councils, the Residue Grant is not administered by local authorities. The whole conditions of government are there utterly different, and the whole grant is administered by the central authority for educational purposes. There, too, as has been pointed out earlier, there has been for many years a fairly efficient system of special education in agriculture. In Ireland, agriculture is of more importance than all the other industries put together.

I think it will be quite clear, then, that as regards technical education, Scotland is at *one* end of the list, and that is ***not*** the

top end. Just as we have seen that the United Kingdom is behind all other great countries in this movement, so Scotland is behind the rest of the United Kingdom. Scotland comes last—not, I should think, a position she will be satisfied to remain in.

I do not wish to leave the impression that in England things are near perfection. Far from it! The greatest fault of the present state to which they have developed is the want of unity of plan. There are far too many different plans being carried out independently by different local authorities. There are far too many diverse and inharmonious ideals. There is a want of some unifying and guiding authority over all. It is a most encouraging characteristic of the movement there, however, that in many instances men of wealth, and influence, and knowledge are taking an interest in it, and assisting in its development. This has frequently saved it from that narrowness and pettiness of aim which has been exhibited in too many cases where it has been left entirely to the management of smaller men.

Agricultural education has received an amount of attention from most of the counties worthy of its importance and its pressing necessities. Of the various schemes, however, undertaken by the different authorities for the education of agriculturists, many have from the very start been foredoomed to failure. These began at the wrong end, by sending out young lecturers to try to teach old farmers. Others, acting more wisely, began by trying to teach the teachers, and have been much more successful. In some places systematic evening classes have been started, and even agricultural secondary schools. One of the most general, and generally successful undertakings, has been the support of dairy schools and dairy teaching. But taking the elementary and secondary education generally, very little useful work has yet been done. There is a great lack of method, of combination, and of even the very rudiments of knowledge of how to set about this part of the work. It seems very difficult to teach the authorities who dispose of this grant that it is essential to make rural schools agricultural schools. Not merely schools with an evening class trying to earn a Science and Art Department grant in agriculture, but elementary agricultural day schools, under the charge of properly trained agricultural teachers. Till we have learnt, what is known by even the Irish education authorities, that it is useless to try to force school-teaching into elderly farmers who are settled in life with wives and families, and whose ideas

and habits of thought are already formed, and who have neither the time nor inclination to come to lectures, and that, to do any good, we must have a thorough-going system designed to catch the young, we shall scarcely have got to the beginning of this question. Such a system should include both elementary and secondary agricultural schools for the young of different classes, as well as higher schools, and provision for turning out properly trained agricultural teachers. A properly graduated system should include training for every class, from the children of the labourers to the professional agricultural specialist. Means should be provided, too, for assisting promising youngsters to raise themselves, if they are able, to a higher rank by means of scholarships. Finally, for the sake of the elders, experiment stations and a system of agricultural experiments are needed, both as a means of increasing and of disseminating knowledge.

I am here sketching no Utopian or impossible scheme, but a practical one, which is in practice in all other highly civilised countries. These are no new or original ideas of my own, but merely indications of what I have seen with my eyes in practice in other countries.

With regard to the higher agricultural education, many of the English and all the Welsh counties have done very well. There is, indeed, just a little tendency to overdo the matter here, and to found too many agricultural colleges. Those counties which have gone in for supporting the agricultural departments of the great colleges have, I think, done most wisely. Many of the new agricultural colleges, founded or being founded, will in time find their level as agricultural secondary schools. The question of experiments and of experiment stations is also exciting considerable interest. Before long there will be quite a number of well-appointed stations in England, and this branch of the work, also, will be adequately dealt with there.

It would be impossible for me to go into details of what the various English and Welsh counties have done. I will, therefore, just take the case of the County Palatine of Lancaster by way of an example. I fear it will also be somewhat of a contrast to what has been done in this district. This great county is in many ways comparable to the West of Scotland district. It is, like the Glasgow and West of Scotland district, a great commercial, manufacturing, and mining district, but its population is much larger than that of the great district of which

Glasgow is the centre, and a very much larger proportion of that population is engaged in commerce, manufactures, and mines, and a very much smaller proportion in agriculture. In Lancashire the agricultural interest is a very small and unimportant one compared with other interests. In the West of Scotland district, despite the great importance of mining and engineering, agriculture far outweighs in importance any other industry.

The county of Lancaster, including its county boroughs, receives for technical education out of the Residue Grant a much larger sum than that received by the whole of Scotland. The county and all its boroughs, with the one exception of Preston, apply every penny of this money to the purpose intended, and, not finding this enough, the county itself and several of its more important boroughs, including Manchester, raise a special rate under the Technical Instruction Acts. From the first this great county has gone into the movement thoroughly. It made itself acquainted with what had been done elsewhere, and is now gradually building up a scheme for itself. Of course, commercial, mining, and manufacturing subjects occupy a very prominent place in its scheme; but in this county, in which of all others one might have supposed that the interests of agriculture would have been in some danger of being overlooked, agriculture occupies a place alongside the other great branches attended to. The higher agricultural education is supported at the Harris Institute, Preston. A dairy school and dairy instructors receive large grants. Elementary teachers are encouraged by money grants to study and teach agriculture. A system of agricultural experiments is supported. Finally, 20 scholarships tenable for three years, and 25 exhibitions tenable for one year, are offered annually to qualified persons wishing to study agriculture. In this branch the county offers more than agriculturists seem, at present, able to make use of. While all the scholarships and most of the exhibitions offered to science, commercial, and art students have been awarded, less than one-fourth of the scholarships and exhibitions offered to agricultural students have been awarded, because a sufficient number of qualified candidates has not been found. This experience has by no means been confined to Lancaster or to agricultural scholarships. One of the greatest difficulties which the whole movement has had to contend with has been the startling illiteracy of men and lads who have passed through our public elementary schools. They are frequently quite unable to profit by the

instruction offered, on account of their own ignorance of the most elementary matters. This merely shows the crying need that their is for better elementary and secondary technical education. Lancaster, in spite of discouragement, continues to offer its scholarships, in the hope that, with the increase of interest in the subject, and with the improvement of earlier education, a sufficient number of qualified candidates will in time be found.

In the neighbouring county of Chester, a district more comparable with the agricultural parts of the West of Scotland, agriculture, very properly, occupies the leading position. This county also applies the whole of its grant, which is over £16,000, to technical education. A farm of 164 acres has been acquired as an experimental station, and a large sum is voted annually for carrying it on. This is one of the counties which is going—very unwisely in my opinion—to found an independent agricultural college. A very large sum has been voted by the county for building and equipping this college, and a still larger sum is being raised outside. This is one of the counties, too, which, like Lancashire and the great county of London, has adopted a very complete system of scholarships. In England and Wales, though opinions may vary as to the wisdom of some of the methods of work, an honest attempt at least is being made to supply agricultural education by means of the Residue Grant.

Let us now turn to the case of Scotland. According to the official returns, the whole amount allocated to technical education, in all its branches, for the year 1893-4 amounted to £40,293 14s.3d. This is certainly a great improvement on the previous year, when the whole amount allotted was considerably under £27,000. In Scotland the grant is far more divided up into little doles than in England. This assures us, from the very start, of far more petty work and far more wasteful work. In England there are 111 authorities (49 county councils, and 61 councils of county boroughs) receiving grants; but in Scotland, with only one-seventh of the population of its bigger neighbour, there are 227 authorities (33 counties, 82 burghs, and 112 police burghs). The consequence is, no single body has a large sum at its command, and there is a great amount of small and incomplete work. Some of the smaller bodies receive only very small sums, and it is these "smaller fry" that chiefly offend by applying the whole of their grant to the relief of rates.

Out of 82 royal and parliamentary burghs, 49, and out of 112

police burghs, 73, misapply their grants in this way. Not a single body has any comprehensive and well-arranged scheme, such as we have seen many of the great English authorities possess. Nor has any one of them, not even the greatest of them, sufficient means from this grant alone to carry out such a scheme. Combination, and the augmentation of the grant, by agitation in Parliament and by raising a rate, are all wanted.

It seems almost incredible that, while so many bodies are applying funds received for technical education to the relief of rates, such an institution as the Scottish Dairy Institute at Kilmarnock should in the year 1894 have to threaten to close its doors for want of financial support. If I wished to pick out a branch of industry which is more susceptible than any other of improvement by special instruction, I should select the dairy industry. We import annually an enormous and increasing quantity of dairy produce, much of which, or at least the best class of which, might be supplied by our home farmers. We possess the finest pastures and the best cattle in the world, yet we are beaten by Denmark and Canada—countries which, besides their inferiority in cattle and pasture, have not climates to be compared with ours for dairy purposes. Why? Simply for the want of the same scientific method of production as the Danish butter-maker and the Canadian cheese-maker have learned. Ireland lost her butter market, not because her butter had deteriorated, but because her competitors had improved. Now that, thanks to Canon Bagot and others, dairy instruction and the factory system have been introduced into Ireland, she is slowly regaining a market. Much of the Irish factory butter, however, is now sold in the London market, not as Irish, as that might prejudice it, but as Norman or Danish. It is very easy to lose your market, but once lost it is very hard to regain. Entrenched behind a good name and a high prestige, it requires a strong force to drive you out, if you but make reasonable use of your advantage; but once let the foreign producer drive you out of your strong position, and it will cost both money and pains to regain it. If dairy instruction can improve our butter and cheese even so little as one per cent., it will not only pay hundreds per cent. on what it costs, by increasing the value of our produce, but it will do an incalculable benefit in enabling our farmers to hold their own market. The Westmoreland County Council estimated that if they could improve the quality of their butter 1d. per lb., it would return the county 5,000 per

cent. on what they were spending on instruction in butter-making. Many English counties have reported an average improvement of 1d. per lb. on the butter of those who had attended their classes for dairy instruction. Some report improvements of 2d. and even 3d. per lb. So, in the case of cheese, an improvement of 10s. per cwt. is frequently reported as resulting from the teaching of the dairy schools. Why, the gain to the community from this dairy instruction alone would, at this rate, pay for the whole technical education of the country in every branch, and give a surplus.

It was the increasing feeling of the need of instruction in dairying which led to the foundation of the Kilmarnock Dairy School. This is the only school of the kind in Scotland so thoroughly equipped as to be on the same footing as the great English dairy schools. Up to the present, whenever Scotland has required dairy teachers, she has had to send to England or elsewhere for them. Now the Kilmarnock school is prepared to turn out fully-qualified instructors and instructresses. As to the value of its practical teaching to farmers, I will quote you the opinions of two gentlemen of authority in this matter, who have been kind enough to supply me with their views. Mr. Andrew Clement, of the Cheese Bazaar, Glasgow, than whom there is no greater authority on this subject in Scotland, and who deals very extensively both with home and foreign produce, writes me as follows:—

"Glasgow, 13th February, 1895.

"After the most careful inquiry that I can make as to the quantity of cheese made in Scotland, I estimate the make of the past year at 9,600 tons, at an average value of £53 sterling per ton, equal to £508,800 sterling. I see from the official returns taken from the Boards of Trade and Agriculture that the estimated value of cheese made in the United Kingdom is £7,403,700, but my opinion is that this is an over-estimate, as I cannot think that Scotland has such a small proportion to the entire make of the United Kingdom. Other countries send us cheese to the value of £5,467,137 sterling. There has been a great improvement in the average quality during these years; this having been brought about, both by itinerant instruction and by the Kilmarnock Dairy School, and Mr. James Smith, of Standingstone, Kirkcudbright, who also opened his dairy as a school during a part of the last two seasons—all of which have done good service to the country, and should have every encouragement, as the public get worse to serve every year, and foreigners are ever studying how to meet our public taste, while our home-producers are slow to learn that what would please the public ten years ago will not serve them now, and it has consequently come to be that we shall have 'a survival of the fittest.' The public want the best of every-

thing, and they don't much mind whether it is home-made or foreign, so long as it pleases them; thus we see how Danish butter is preferred to much of our home make, and finest Canadian cheese are preferred to anything except our very finest home cheese, hence the need of *all* being finest. While I have quoted 53s. as being as near as I can make out an average for our whole make of Scotch cheese for the last year, there was quite a quantity of them sold by farmers at 60s., while up to 66s. was paid for the very top. If the average could be lifted, say, even 4s. per cwt., this would mean a gain to the country of £38,400, and this could be easily done. I think we have gained about 5s. per cwt. in quality, on an average, during the last ten years, or £48,000 a year. Surely the paltry sum required to keep up two dairy schools and two instructors should not be grudged, more especially as there is generally a demand for finest quality, while the poor are hard to sell, even at the lower price."

Then I have the following from Mr. J. Harling Turner, of the Portland Estate Office, Kilmarnock, whose very extensive connection with Ayrshire farms and farmers, as well as his close connection with the Kilmarnock Dairy School, enables him to speak with great authority on this question. Mr. Turner writes:—

"Kilmarnock, 7th February, 1895.

"I will gladly give you any information in my power showing the benefits derivable from the teaching given by the dairy school. I know myself of cases where farmers have gone on upon the old lines, and where there is a difference of from £5, £10, £15, to even £20 a ton, in the prices obtained from their cheese. I recollect when I made a minute inquiry into the matter, for the purpose of giving evidence before Sir Richard Paget's Departmental Commission on Dairying, that I took three farms, adjoining one another, as a good example of what had been done by Farmer A having adopted the system of cheese-making as taught by Mr. Drummond. Prior to the instruction, you may take it there was practically little or no difference between the prices obtained by Farmers A, B, and C for their cheese. After Farmer A had started the Drummond system, he obtained £15 a ton more for his produce than his neighbours B and C. B then took instruction in the new method, and reduced the difference between the price received by A to about £6, C still keeping about the old figure. The following year C thought it was time to move, and the consequence now is that B and C are equal, but A, on account of having obtained a good start and a great reputation in the West of Scotland as a cheese-maker, has always been able to obtain top prices in the markets, equal to 2s. or 3s. a cwt. over his neighbours. I have the best authority for saying that a farmer living within two miles of the farms occupied by A, B, and C (and I am sorry to say that he is on the Duke of Portland's estate), still goes on with the old principle of cheese-making, and receives from £15 to £20 less for cheese than A, B, and C. I could give you many other instances of the value of the instruction given at the dairy school, but I have no doubt the above will serve your purpose."

I might also refer to the evidence of the prize list of the Kilmarnock Cheese Show, which demonstrates the value, as far as prize-winning goes, of educated cheese-making.

This very plain and striking illustration of the value of agricultural education refers only to one branch; but what is true of dairying is also true of other departments of agriculture, though it may not always be so easy to demonstrate it in such a plain and forcible manner. Agricultural education far more than pays. If by this means we could improve our agriculture only one per cent., it would result in an increase of some £3,000,000 annually in the resources of the country. Surely it is a profitable investment to spend a few thousands, or a few hundred thousands, to achieve such an object. All the evidence, too, goes to show that we can effect a greater improvement than one per cent. by a proper system of agricultural education. Further, it is not merely a question of improving our production a certain percentage. The good does not end here. The real question is—Are we to be able to keep our own markets and utilise our own land? If we bring about such conditions that we shall be able to utilise our own land for productive purposes to its fullest extent, we shall have so many fewer millions to pay to the foreigner for his produce. But unless we teach our farmers to produce the *best*, and only the best, and to modify their systems so that they shall produce only what they can produce of the best quality, they will be driven from their markets by *good* and cheap foreign produce, unless, indeed, we are prepared to resort to some drastic measure of protection.

I shall beg your indulgence now for a few moments while I make, with all diffidence, a few suggestions as to what we ought to do:—(1) All the money which is granted for technical education should be spent on it; and (2) such an increase on this grant should be obtained as will place us on an equal footing with towns and counties across the border. Then, instead of every little local body which has a dole of a few pounds to spend frittering it away in its own foolish little way, surely the whole of the West of Scotland district could agree to some sort of combination for carrying out a large and thorough scheme for the whole district. Combination is at least needed for carrying out the higher agricultural education. One agricultural college, such as that which we already have in the agricultural department of the Technical College, ought, if properly supported, to be sufficient to supply the needs of the

whole district for the highest branches of the subject. There should be a system of local scholarships organised to enable the cleverer youths of poor parents to take advantage of this education, and raise themselves to a higher level. Further, instead of beginning at the wrong end, and trying to patch up both farmers and teachers after they are almost past the need of it, we should begin with the young in agricultural schools. It is absurd, too, that the teachers at training colleges, who are going out to teach in country districts, are not bound to make themselves fairly proficient in the scientific principles connected with agriculture. Elementary schools of a distinctly agricultural character should be founded in all districts, and properly qualified teachers, whose whole training has had a distinctly agricultural trend, put in charge of them. Secondary agricultural schools, too, should be founded at all the chief county centres. Finally, there is need for support to special teaching, such as that of the dairy schools, and for the foundation of an agricultural experiment station, properly furnished both for purposes of instruction and for carrying on scientific research. Then we must not expect, when we have spent a few thousand pounds in doing this, to find an immediate revolutionary change in the whole face of nature, and all agriculturalists happy and prosperous. Nor must we proceed to undo in a "pet" all we have done, if we cannot at once see wonderful visions of bounteous increase; but remember that, even if a one-per-cent. improvement is affected—a change for the better that would be hardly perceptible to the gross vision of an ordinary unskilled observer,—still even that slight improvement will far more than repay us for the few thousands spent on the education and research necessary to bring it about. When we have done all this, we shall at least have removed one of the disabilities under which our agriculture labours in its unfair competition with the foreigner.

X.—*Smoke Abatement with reference to Steam Boiler Furnaces.* By GEO. CARRUTHERS THOMSON, F.C.S., Engineer to the late Smoke Abatement Association. *(A Communication from the Sanitary and Social Economy Section.)*

[Read before the Society, 6th February, 1895.]

IN venturing to touch upon this oft-discussed subject, I do so at the urgent request of the President of the Sanitary Section.

I cannot promise that you will hear anything very new or striking on the subject from me, but your memories may be refreshed, and your spirits encouraged to fight and conquer the means by which the glorious sunlight is so much and so often shut out from lighting up the streets and byways of our great city.

As a Section, you are engaged in fighting with all that militates against the health of the individual and of the community. Matter in the wrong place is one of the foes that you have to deal with, and presuming that black coal smoke, as emitted from the boiler chimneys of our factories, is included amongst these foes, and considering it as such, I purpose taking it as the subject of discussion to-night.

I shall deal more particularly with coal and its combustion, causes of smoke emission, the effect of different methods of firing in abating smoke, and how best to enforce or carry into practice the available knowledge of the subject to ensure a smokeless city.

The complaints about smoke nuisance are not new, and seem to have existed ever since the use of bituminous coal as fuel began. In support of this statement, I find that Professor Vivian B. Lewes, in a paper read before the Institution of Sanitary Engineers (*Journal of Gas Lighting*, 1894, page 1,213), mentions that the use of coal of a bituminous character was first introduced for use as a fuel in the thirteenth century; but the smoke to which it gave rise appeared so serious a drawback to those who were unaccustomed to it that, in 1306, a decree was passed forbidding its employment.

Further, Dr. F. Fischer, Hanover, in a paper read before the Hanoverian Section of the German Society of Engineers, mentions the following lists of enactments regarding the smoke nuisance:—"In the year 1348 the town council of Zwickau strictly prohibited the use of coal by the blacksmiths whose smithies were situated just before the town gates. In the beginning of the fourteenth century the English Government was implored to forbid the use of coal. In the end of the sixteenth century Queen Elizabeth passed a law against the pollution of the air by coal smoke. Despite this, however, the nuisance to the residents of London was so great that, in the beginning of the seventeenth century, a Government commission ordered the destruction of all furnaces using coal, and forbade the use of coal as a fuel. In 1673 new laws against the smoke nuisance were necessary, followed by others in 1773 and 1821. In 1843 it was enacted that each locomotive should consume its own smoke. In 1853 the Smoke Nuisance Act appeared, followed by the Smoke Nuisance Amendment Act in 1858. In 1863 the Alkali Act appeared, and in 1866 the Nuisances Removal Act, and, later, the Public Health Act of 1875, were brought out, but neither these numerous laws, nor the smoke abatement exhibitions of London in 1881-82, and Manchester in 1882, have had the desired effect of doing away with this old-standing complaint." (See *Zeitschr. f. angew. Chem.*, 1889, 8.)

In the beginning of the present century this subject was investigated by Count Rumford, who said he never "viewed from a distance the black cloud of unconsumed coal which hangs over London without wishing to be able to compute the immense number of chaldrons of coal of which it is composed."

In Scotland the use of coal as fuel can boast of some antiquity, as we find that the monks of Newbattle received a grant of a coal mine from Seyer de Quinci between the years 1210 and 1219; and the monks of Dunfermline, in 1291, received a grant of a coal mine on the lands of Pittencrieff from William de Oberwill; while there is in existence an "indenture between the abbots of Dunfermline and Newbattle with regard to working of the coal at Preston-grange, dated 1531." (See "Early Records of Mining in Scotland," by R. W. Cochran-Patrick of Woodside.) No mention is made in these records of smoke nuisance, the probable reason being that those who used the coal had usually the power to deal summarily with such persons as might complain, and who

usually were little better than serfs or slaves, to whom the masters' words or deeds were laws that could not be disputed.

Coming down the centuries till within the memories of those present, we find that the following laws have been enacted:—

"An Act for the Abatement of the Nuisances arising from the Smoke of Furnaces in Scotland," dated 25th August, 1857—

"Every furnace employed, or to be employed, in the working of engines by steam, whether locomotive or otherwise, in any place to which this Act shall apply, or on board of any steam vessel stopping at or in any such place, or in or at any port, pier, landing place, or harbour within the same, or when plying on any part of a river which at any such part shall not exceed a quarter of a mile in breadth, and every furnace employed or to be employed in any mill, factory, &c., shall in all cases be constructed or altered so as to consume or burn the smoke arising from such furnace," . . . "Provided always, that the words 'consume or burn the smoke' shall not be held in all cases to mean 'consume or burn all the smoke.'"

"The City of Glasgow Police Act, 1866."

"The Public Health (Scotland) Act, 1867," says:—

"Any fireplace or furnace which does not as far as practicable consume the smoke arising from the combustible matter used in such fireplace or furnace, and is used within any burgh for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufactory or trade process whatsoever.

"Any chimney (not being the chimney of a private dwelling-house) sending forth smoke so as to be injurious to health."

"The Glasgow Police (Further Powers) Act, 1892, Section 31," says:—

"Every person who so uses, causes, permits, or suffers to be used, any furnace or fire within the city (except a household fire), as that smoke issues therefrom, unless he proves that he has used the best practicable means for preventing smoke, and has carefully attended to and managed such furnace or fire so as to prevent, as far as possible, smoke issuing therefrom, shall be liable for the first offence to a penalty not exceeding forty shillings, and for a second or any subsequent offence, if committed within twelve months of the immediately previous conviction, to a penalty not exceeding five pounds."

This is the same clause as occurs in the Act of 1866, with the exception of the penalty, which has been increased.

For the carrying out of the Acts of 1866 and 1892, the City of Glasgow is divided into districts, which are under the charge of District Superintendents, who are themselves directly under the supervision of the Chief Constable.

Regarding the smoke nuisance, each District Superintendent sends in to the Chief Constable observations of chimneys made within his district every week. For this purpose he details off a sergeant and constable, whose duty is to go and take observations. Each observation must last one hour, during which time the constable must not lose sight of the chimney top, and the observations must be taken from two different points of view. After taking the observation, he must give notice to the owner or manager of the works, stating the fact of an observation having been made during a certain period of time.

The report to the Chief Constable bears that the chimney in question emitted, say, between 11 a.m. and 12 noon, during so many minutes dense or black smoke, so many minutes light grey or whitish smoke, and so many minutes no smoke.

It is held that dense or black smoke may be any colour, so long as one cannot see through it, and in the prosecutions under the Act this is the meaning attached to the term black smoke. I trust you will not take away the impression that the chimney under observation must have emitted black smoke during the hour. It is just as likely as not that no smoke was emitted, and the report would bear this.

All these reports are submitted by the Chief Constable to the Procurator-Fiscal, who examines them, and decides whether there shall be any prosecutions instituted or not. In this way every chimney stalk in Glasgow is reported upon regularly. In no case is the Procurator-Fiscal bound to prove more than that smoke issued from the chimney, irrespective of the density or colour of such emission. Practically, however, until lately, no prosecutions have been instituted unless there has been some emission of black smoke, and unless there had been ten minutes of black smoke in the hour no conviction could be obtained.

Within the last few months, owing to the increased annoyance from the smoke nuisance, the allowance has been reduced to the following standard:—Two minutes black smoke, three to five minutes medium, and fifteen minutes very light smoke per hour, beyond which prosecutions will be instituted.

It lies with the accused to show that such emission was unavoidable, and that he had done all in his power to abate said emission. The burning of bad coal, so far from being taken as an excuse, will be held as a proof that due care has not been exercised in the management of the furnace or furnaces in question.

I am indebted to the courtesy of Mr. George Neilson, Procurator-Fiscal to the Glasgow Police Board, for the following statistics:—

"Central Police Chambers,
"Glasgow, 24th January, 1895.

"Geo. Carruthers Thomson, Esq.,
"273 Central Chambers.

"MY DEAR SIR,—In reply to your inquiry, I beg to inform you that the following is the record of smoke cases in 1893 and 1894:—

"Under Glasgow Police (Further Powers) Act, 1892—

	1893.	1894.
Observations taken,	1,279	1,257
Prosecutions,	44	77
Convictions,	30	58
Total fines,	£24 5 6	£25 0 6
Highest and lowest fines, 40s. and 7s. 6d.		
Cases found not proven,	14	19
Cases prosecuted as serious offences,	9	8

"The smoke cases in the River Bailie Court, I am informed, were as under—

	1893.	1894.
Prosecutions,	29	55
Convictions,	29	53
Not proven,	—	2
Total fines,	£15 14 6	£27 16 6
Highest fines,	£1 1 0	£1 1 0
Lowest fines,	£0 10 6	£0 10 6

"Yours faithfully,
(Signed) "GEO. NEILSON."

In contrast to these, I give some statistics of observations on chimneys in Glasgow during the 21 months ending September 30th, 1888, previous to the extension of the city boundaries, with notes which I received from Mr. Donald M'Phee, late Procurator-Fiscal to the Glasgow Police Board:—

"Number of Observations in 1887,	671
,, Prosecutions ,,	85
,, Convictions ,,	56
,, Not proven ,,	29

Total amount of fines, £36 13s. 6d.*
Highest and lowest fines inflicted, 40s. and 10s.

* "This does not represent expense to which defenders may have been put in establishing their defence by the evidence of experts, nor the trouble and annoyance which they and their employés may have incurred through these prosecutions. They are sufficiently annoying in many cases, it is believed, to lead many to improve their furnaces, &c., even at considerable cost, to avoid them."

"Besides the above, there were 25 prosecutions in the River Bailie Court of masters of steam vessels for smoke nuisance in the harbour.

"Uniform fines or forfeitures of 10s. 6d, were obtained in all except one case, bringing into the city a total of £11 0s. 6d.

"Yours truly,
(Signed) "D. M'PHEE."

"1st January to 30th September, 1888.

"Number of Observations in 9 months,	...	... ...	666
,, Prosecutions	,,	... ...	52
,, Convictions	,,	... ...	32
,, Not proven	,,	... ...	15

"Of the convictions, 10 were admonished and 22 fined in a total sum amounting to £20 12s. 6d.

"In the Marine Division there were 17 prosecutions, yielding £8 7s. 6d. of fines."

The increased interest taken in this subject is no doubt largely due to the work carried out by the Glasgow and West of Scotland Smoke Abatement Association, and also to the efforts put forth by the Section from a sanitary point of view. Before proceeding further, it may be as well to consider the composition of coal and its combustion. With regard to the physical aspect of coal, I do not think it is necessary to give any description, as you are all well aware of its appearance, and the use to which it is put. I give the analysis and products of the complete combustion of some of the coals used in this district.

DROSS FROM DOUGLAS PARK COLLIERY.

Analysis.

Carbon, ...	58·48 per cent.	...	1309·95 lbs.
Hydrogen, ...	4·49 ,,	...	100·58 ,,
Oxygen, ...	8·87 ,,	...	198·69 ,,
Nitrogen, ...	1·61 ,,	...	36·06 ,,
Sulphur, ...	2·17 ,,	...	48·61 ,,
Ash, ...	16·54 ,,	...	370·50 ,,
Moisture, ...	7·84 ,,	...	175·61 ,,
	100·00 per cent.		2240·00 lbs.

Products of Combustion.

Carbonic Acid, ...	4803·63 lbs.
Water, ...	1080·83 ,,
Sulphurous Acid, ...	48·61 ,,
Nitrogen, ...	36·06 ,,
Ash, ...	370·50 ,,
	6339·63 lbs.

Air required to supply the necessary amount of oxygen to effect complete combustion of one ton of this fuel is 18,261·78 lbs.

TRIPING FROM ALLANSHAW COLLIERY.

Analysis.

Carbon,	66·20 per cent.	1482·88 lbs.
Hydrogen,	4·49 ,,	100·58 ,,
Oxygen,	10·61 ,,	237·66 ,,
Nitrogen,	1·78 ,,	39·87 ,,
Sulphur,	1·00 ,,	22·40 ,,
Ash,	6·48 ,,	145·15 ,,
Moisture,	9·44 ,,	211·46 ,,
	100·00 per cent.	2240·00 lbs.

Products of Combustion.

Carbonic Acid,	5437·77 lbs.
Water,	1116·68 ,,
Sulphurous Acid	22·40 ,,
Nitrogen,	39·87 ,,
Ash,	145·15 ,,
	6761·87 lbs.

Air required for combustion of one ton of this coal is 20,097·60 lbs.

The sulphur in coal is generally in the form of iron pyrites as a mechanical impurity, but it also exists in the form of an organic compound, as shown by the late Dr. William Wallace, City Analyst, in a short paper read by him before this Society on 5th April, 1880. In the foregoing instances I have taken the half of the sulphur to be volatile, and the remainder as retained in the ashes.

If a shovelful of coal is placed upon a bright fire the following action takes place:—The temperature over the fire is lowered considerably by the cold fuel intercepting the heat; in a few minutes the upper surfaces of the fuel become moist, then vapour is given off in jets from the cracks in the fuel, and passes away; as the temperature increases, these streams of vapour become ignited; and when the volatile constituents of the coal have been burned off, the remaining coke, or fixed carbon, as we may call it, remains as a glowing, incandescent mass.

Without the presence of air, this could not have happened, as the air passing through the fire-bars and coming in contact with the incandescent coal parts with its oxygen to the carbon of the fuel, forming carbonic acid. This gas, passing upwards through the mass of incandescent fuel, loses an atom of oxygen to the carbon, and forms carbon oxide, which, on reaching the upper surface of the fuel, and meeting a fresh supply of air, takes up more oxygen, becoming carbonic acid again, and passes away

through the flues to the chimney, and, if the air supply has been sufficient, the escaping gases will be invisible.

Suppose, however, that the charge of fresh fuel to the furnace had been very heavy, so that a thick layer of coal was lying upon the surface of the glowing fuel, the effect would be as follows:—As the temperature of the furnace is lowered very greatly by the heavy layer of cold fuel, the tarry vapours being distilled from the coal would pass away without being ignited, and the carbon monoxide gas coming up through the fire, being cooled by the mass of cold fuel, would not be able to combine with the oxygen of the air, and so would pass off with the distilled gases from the coal, which, becoming cooler as they rose, would deposit carbon in an unburnt state, and the escaping vapours or gases would present the appearance at the top of the chimney, with which we are all so familiar, of fine rolling masses of smoke in varying degrees of density and colour. Along with the soot particles and tarry vapours, the moisture in the coal escapes as steam, and the draught also carries up the finest particles of the ashes. A portion of the sulphur in the coal is also oxidised to sulphurous acid, and escapes up the chimney, while the remainder is combined with the ash and clinker.

To get the best effect from our fuel, only so much air should be admitted as is actually necessary—one portion going up through the fuel, and the other portion passing through the gases emanating therefrom; and these two supplies should be adjusted to meet the varying demands as decomposition progresses.

If the air supply is too scanty, we produce smoke, and send carbon monoxide up the chimney, which is a loss, as carbon burned to carbon monoxide gives out only one-third of the heating power of carbon burned to carbon dioxide; and if we admit too much air to the furnace, we require to use a portion of the fuel to send it up the chimney, and also larger flues and chimneys for the removal of the greater volume of gases to be disposed of.

When a furnace is charged with fuel, a large quantity of cold air rushes in by the open door, and cools the upper surface and area of the furnace chamber. When the fire is low, and least air is required, it gets most; and after firing up, when most air is needed, it gets least, owing to the difficulty of getting through the mass of fuel, and the air supply to the furnace is so irregular that a thorough admixture is impossible.

For the efficient and economical use of coal as a heating agent,

space is required, so that the air may be properly mixed with the gases evolved during combustion of the coal, and this, of necessity, requires that time be allowed to secure the desired result. This fact is well known to all who have experimented with flame, and observed the cooling effect of small tubes as compared with those of larger diameter.

The conditions of perfect combustion are very simple, but are not always attended to or provided as they ought to be. They are as follow :—First, an adequate supply of air; second, the air must be brought into contact with the fuel, both solid and gaseous; and, third, the mixture of the gases must be kept for a sufficient time at the temperature of incandescence.

The emission of black or dense smoke from factory stalks or chimneys is mainly due to one or other, or a combination, of the following causes :—

1st. Badly proportioned or badly constructed furnaces, flues, and chimneys.

2nd. Forcing the boilers, or attempting to get more work out of them than can be taken under the given conditions.

3rd. Careless firing, whether by hand or machine.

I.—Proportions of Furnaces, Flues, and Chimneys.

In reference to the furnaces, the fire-bars should never be more than 6 feet in length, unless under very exceptional circumstances, as it is not possible for a fireman to manage a fire properly and keep the bars covered if they are longer; in many cases, indeed, it is advisable to make them shorter.

As the gases require both time and space to mix thoroughly with the air, the flues should be of sufficient size that they can be properly cleaned out, and have a sectional area, in any case, of not less than $\frac{1}{6}$th to $\frac{1}{5}$th of that of the fire-grate surface, which experience has shown to be about the best proportion.

Where several boilers are laid down side by side, the flues from each boiler should be led into one main flue, which ought to be of larger area than is actually required, in case of the addition of more boilers.

The distance between the main flue and the chimney should be as short as possible, and the height of the chimney ought never to be less than 100 feet, whether the factory is in the town or the

country. If surrounded by high buildings, or placed in a hollow, it should even be higher, as when it is lower than the surrounding buildings a down draught is the result when the wind blows in certain directions.

The area of the outlet at top of chimney should not be less than the area of the main flue, so that a good draught may be under the command of the fireman, and so enable him to deal with different qualities of fuel as occasion may require him to do so. A coal that burns freely with little ash and does not clinker can do with a quarter of an inch water gauge, where a coal that had a large amount of ash and clinkered badly would require treble that amount, and a frequent use of the slice, to keep the same steam on the boiler.

II. — FORCING THE BOILER, OR ATTEMPTING TO GET MORE OUT OF IT THAN CAN BE TAKEN UNDER GIVEN CONDITIONS.

This is a very common fault, and is the cause of a large proportion of the smoke nuisance. It generally arises from extension of the business of the steam-user, who does not take into consideration the fact that his boiler can only supply a certain amount of steam economically, and a further portion only by great waste of fuel, and who tries then to do impossibilities rather than face the expense of a larger boiler, or an additional boiler, as the case may be.

A boiler, for instance, with a very poor and weak draught, and using a very dirty and clinkering coal, may not be equal to the task imposed on it, while the same boiler, by having the draught increased or strengthened, and using a freer burning and cleaner kind of coal, may be quite equal to the duty required from it.

In many instances, however, the boiler is expected to do more than is possible in the way of heat transmission, and in these cases the only cure is more boilers.

Wherever doubt exists as to the duty of a boiler or boilers, it is advisable to call in the services of a skilled expert to determine what is the best thing to do in the circumstances.

In Lancashire boilers, 16 to 20 lbs. of coal burnt per square foot of grate area, and 20 to 25 square feet of heating surface per square foot of grate area, have been found to be safe practice, and boilers working with these proportions can be easily kept smokeless, if other conditions are attended to.

III.—Careless Firing, whether by hand or machine.

This is a fruitful source of the emission of black or dense smoke, and it may be as well to describe the various modes of firing in general use, and show their effects on the smoke emitted.

Hand Firing.—This may be classed under the following—namely, spread, alternate, side, and coking firing.

Spread Firing.—In this method the coal is spread evenly over the whole surface of the fire, so that what was a red glowing mass when beginning is changed to a black surface on the top. The effect of this is to cool down the furnace, and the gases given off from the freshly fired fuel, not having enough heat to ignite them, pass off at first unburnt, and afterwards partly burnt, as the heat increases, and latterly, when all the volatile gases have passed off, smoke ceases, and the furnace attains its red glowing character again. The result of this method of firing is that dense volumes of smoke are given off immediately after firing, and the steam pressure falls, to rise again before the next charge of fuel is put on the fire.

Alternate Firing.—Where the boiler has two furnaces, the fuel is spread, as in the previous system, over one furnace, and when the volatile gases have been burned off, and the fixed carbon is glowing, the other furnace is charged, and so on, alternately. By this method the smoke emission is reduced very considerably—in the hands of a skilled fireman to a minimum, while the steam pressure is much steadier.

Side Firing, alternate.—In this system the furnace is supposed to be divided in two in the direction of its length. While the furnace is in a red glowing condition, the coal is charged along the one-half of the furnace, right back to the bridge; the door is then closed, and the volume of the gases from the fuel just charged is allowed to pass off, becoming ignited from the other half of the fire surface, which is hot enough to ignite them. As soon as this has taken place, and the surface of the fuel is again red and glowing, the door is opened, and the other half of the fire is now covered with fresh fuel, the door is closed, and the operation is again repeated. In this way the temperature of the furnace is maintained at a much higher level; there is no danger of the gases passing off before ignition, and no smoke is emitted from the chimney top, as smoke, in fact, has never been allowed to form;

the steam pressure also remains steadier; and the full benefit is taken out of the coals.

Coking Firing.—This method consists in the heaping up of the fuel on the dead plate at the mouth of the furnace, and, before a fresh charge is added, pushing it back towards the bridge, while the fresh charge is placed on the vacated part. The gases thus have to pass over the red fire and are ignited, and where there is plenty of boiler power, and time is given to allow the fuel to be nearly burned out by the time it reaches the bridge, there is practically no smoke. In the majority of cases this state of affairs does not exist, and, in consequence, the coal is hurried forward, with the result that smoke is emitted in varying degrees of density.

The foregoing methods are those which can be followed by firemen with varying degrees of success, according to their individual skill. By the first method the emission of smoke can, when ample boiler power is present, be reduced to a very small amount, especially if the fireman takes care not to put a large amount of coal on the fire at once, but by firing in small amounts at a time, and more frequently. In the second and third methods the emission of smoke can be so far reduced that the chimney can be declared smokeless, save when breaking up fires after meal hours and cleaning. In the fourth method the emission of smoke can scarcely be avoided, owing to the stirring of the fire in shifting the fuel towards the bridge, and this method is not so frequently used as the first method, which is almost universal.

An unskilful fireman often fails to keep the furnace bars covered near the bridge, owing to his causing the coals, after leaving his shovel, to strike the top of the furnace very near to the door, thus causing them to fall short of the distance intended; and this fault is intensified when the bars are long—the result being that an excess of cold air is admitted between the fire and the bridge, which air has to be heated and carried up the chimney, and so causing the evaporation per lb. of fuel to be less than it ought to be. With an ordinary furnace, the bars should not be longer than 6 feet, and in many cases it is advisable to make them shorter. It is better to keep the fires thick, and allow a little air to enter in thin streams at the door, than to have the fires so thin that in some places they are left bare. When this occurs, it is better to shorten the bars, so that the fires may be kept thicker. By keeping the door of the furnace slightly open for a minute or two after firing, the emission of smoke is prevented.

Machine Firing.—The supply of skilled and attentive firemen being small led to the introduction of mechanical means of stoking. Of these there are two well-defined systems in use at the present time—shovel-sprinkling stokers and coking stokers.

Shovel-sprinkling Stokers.—In sprinkling stokers the fuel is deposited on the bars, in imitation of hand-firing, by means of shovels actuated by springs, whose throw is determined by means of cams constructed to discharge the fuel on the bars in, as a rule, four different places. With stationary bars, this was not found to do well, so the bars are now made to move a few inches to and fro, in order to level the fuel; the ashes are carried back over the ends of the bars and fall into the flue tube, and can be removed when found necessary. Dampers require to be fitted in all cases below the ends of the bars, or the ashes must be banked up to prevent an excess of air being admitted. The emission of smoke under this system varies from very little to a considerable amount, and, when full work is required from the boiler, a considerable amount is emitted from the chimney.

Coking Stokers.—In coking stokers the fuel is pushed forward on to the dead plate, and so reaches the bars, which are invariably made movable, and carry the fuel forward, throwing the ashes over the back end of the fire-bars into the flue tube. As in the case of the sprinkling stokers, the same precautions have to be taken to prevent an excess of air being admitted. Coking stokers, as a rule, emit less smoke than sprinkling stokers; but when firing is pushed, they generally make just as much smoke as the other sort; and both systems, when pushed hard, send out dense black smoke in quite as continuous a stream as any hand fireman is able to do.

Most of the mechanical stokers in use are fitted with doors on the furnace fronts, so that, in case of accident to the machine, the fires can be kept up by hand-firing, and full advantage is often taken of the presence of the door to combine hand-firing with mechanical stoking when there is no necessity for doing so. The result of this is smoke emission.

The advantage of using mechanical stokers is found in the use of a cheaper and poorer class of fuel, and in attaining a greater evaporative efficiency by their use than is generally found or obtained by the use of the same fuel in the hands of an ordinary fireman. Their disadvantages are that they require the fuel to be small, otherwise they cannot cope with it; that they require an attendant

with more knowledge of machinery than is found in the average unskilled labourer usually employed as fireman; and that, in the case of the boiler being hard-pressed, the mechanical stoker cannot meet the extra demand on it as well as a skilled fireman can do, more especially if the demand is very variable. In the great majority of cases, mechanical stokers require a certain amount of steam to be admitted below the bars to keep them cool and prevent them melting down. This is an absolute necessity, unless where there is a very strong draught.

From these remarks on firing by various methods, it is obvious that, by taking ordinary precautions, and suiting the system of firing to the quality of fuel and the other conditions present, the emission of dense black smoke can be done away with; and by a reference to Table No. I. (pp. 162, 163), giving a statement of the results of the examination of steam-boiler furnaces, abstracted from the 29th Annual Report of Alkali, etc., Works, by the Chief Inspector, Mr. Alfred E. Fletcher, and also to Table No. II. (pp. 164, 165), giving a summary of the results of evaporative tests on steam boilers, compiled from the trials carried out by me for the Glasgow and West of Scotland Smoke Abatement Association, this statement is fully borne out.*

A further consideration of these tables also shows that, where the percentage of carbon dioxide gas is high and the oxygen low, the water evaporated per lb. of fuel is high, as is also the percentage of the heating power of the fuel utilised in heating water.

These results show, further, that, by care and attention to the firing of steam boilers, their evaporative efficiency can be increased with advantage to boiler owners without the emission of black smoke from the top of the chimney. This increase of efficiency may vary from 10 to 25 per cent., which may be all that is required to enable boilers, at present in difficulties, to do what is required of them, and still remain within the limits of economical use of fuel. It is well known that there are no two factories working under the same conditions in all respects, and it is, therefore, perfectly evident that there can be no form of apparatus which can be universally applied to meet all conditions under which boilers are working, with the view of preventing the emission of smoke.

* For full details of these results I must refer you to my paper "On Results of Evaporative Tests on Land Boilers," read before the Institution of Engineers and Shipbuilders on 18th December last.—G. C. T.

TABLE No. I.—RESULTS OF THE

DESCRIPTION OF APPARATUS USED FOR FIRING.	SINCLAIR'S COKING STOKER.		BENNIS' SPRINKLING STOKER.		PROCTOR'S SPRINKLING STOKER.
DESCRIPTION OF BOILER.	1 Lanc. Boiler, 8ft.×30ft. 6 Galloway tubes in each flue.	Lanc. Boiler, 8ft.×30ft. No tubes.	Lanc. Boiler, 7ft.×30ft. 6 Galloway tubes in each flue.	Lanc. Boiler, 8ft.×30ft. No tubes.	Lanc. Boiler, 6 ft. 5 in.× 30 ft.
Duration of Trial, - - - - Hrs.	10	10	10	9½	—
Average Steam Pressure, - - Lbs.	88	92	66	82	49·8
Temperature of Feed Water, - - °F.	274	272	254·8	45	69·5
,, Exit Gases, - °F.	278	341	400	—	475
Draught by W.G. at end of fire flue, Ins.	0·20	0·50	0·325	0·6	—
Kind of Coal used, - - - -	Westhoughton Arley Mine. Good Rough Slack.		2nd best or 6 feet.	—	Denaby Nuts.
Coal used per hour, - - - Lbs.	711·2	1005·2	929·6	1008·0	518·8
Coal used per sq. ft. grate area, - ,,	23·45	33·15	23·24	—	20·42
Percentage of Ash weighed, - -	12·4	11·00	—	10·4	6·55
Analysis of Coal, Carbon, - - - - °/°	72·94	72·94	68·00	70·69	74·50
Hydrogen, - - - - ,,	4·56	4·56	4·78	4·55	5·07
Moisture, - - - ,,	3·15	3·15	5·20	1·90	6·87
Ash, - - - - - ,,	6·69	6·69	16·53	10·94	3·60
Calorific Value, - - - B.T.U.	13,080	13,080	11,250	12,270	13,480
Carbon Value, - - - - Ratio	0·899	0·899	0·774	0·844	0·927
Water evaporated per hour, - Lbs.	5711·4	7682	7097·5	6930·5	4015
,, per lb. of Coal from and at 212° Fahr., - - - ,,	7·74	7·25	7·52	8·30	9·09
,, per lb. Carbon Value from and at 212° Fahr., - ,,	8·60	8·06	9·75	9·83	9·81
Analysis of Gases of Combustion, Carbon Dioxide, °/° vol.	10·18	11·57	5·21	9·87	7·29
Carbon Oxide, ,,	—	—	—	—	—
Oxygen, - ,,	9·22	6·50	14·11	6·63	12·55
Nitrogen, - ,,	80·60	81·93	80·68	83·50	80·16
Smoke, - - - - - - -	None.	No Observation.	No Observation.	None.	—
Coal utilised in heating water, - °/°	57·70	55·06	64·70	65·43	65·15

This Table is abstracted from the 29th Annual Report on Alkali,

Examination of Steam Boiler Furnaces.

Vicars's Coking Stoker.		Cass' Patent Coking Stoker.				Hand Firing.			
						Caddy Bars and Louvre Doors.	Caddy Bars.	Split Bridge.	Broadbent's Doors.
Lanc. Boiler, 7ft.×30ft. 6 Galloway tubes in each flue.	Lanc. Boiler, 8½ft×30ft. 9 Galloway tubes in each flue.	Lanc. Boiler, 7ft.×30ft. No tubes.	Lanc. Boiler, 8ft.×30ft. 6 Galloway tubes in each flue.	Lanc. Boiler, 7ft.×30ft. No tubes.	Lanc. Boiler, 8ft.×30ft. 35 Galloway tubes in each flue.	Lancashire Boiler, 8 ft. 6 in. dia. × 34 ft. long. 9 Galloway tubes in each flue.			Lanc. Boiler. No tubes.
10	10	10	10	10	10	10	10	10	10
80	90	74	86·1	80	40·5	85	85	85	60
239·5	210	183·75	250·45	240	193·5	215	215	205	—
330	320	—	—	375	245	—	340	350	557
0·3	0·4	0·15	0·475	0·45	—	—	—	—	0·4
Best Arley Slack.	Bridgewater Good Slack.	—	—	—	Fine Gingham Slack.	Bridgewater Good Rough Slack.			Bridgewater Good Slack.
630·6	980	489·4	925·8	544·3	1220·8	1008	929·6	929·6	3449·6
22·93	—	15·53	—	—	—	—	—	—	—
13·2	11·7	16·6	10·0	10·2	25·7	10	13·25	13·55	14·6
76·90	67·67	70·76	71·90	69·56	60·08	67·67	67·67	67.67	66·75
5·00	4·37	4·10	4·87	5·72	3·56	4·37	4·37	4·37	4·45
2·10	9·11	2·50	2·07	2·45	3·16	9·11	9·11	9·11	3·22
6·66	6·60	10·92	9·87	8·56	21·06	6·60	6·60	6·60	11·37
12,740	11,900	12,020	12,950	12,150	9,740	11,900	11,900	11,900	11,470
0·876	0·818	0·826	0·890	0·835	0·669	0·818	0·818	0·818	0·788
5584·5	7348	4124·9	7320·1	4091·5	8696·9	7682	7181	7181	24716
8·9	7·77	8·94	7·82	7·52	7·42	7·87	7·97	8·05	—
10·15	9·49	10·82	8·78	9·00	11·09	9·62	9·74	9·84	—
8·85	13·82	10·00	8·25	15·51	12·50	8·71	9·43	11·77	9·40
—	—	—	—	—	—	—	—	—	—
8·40	4·79	6·50	10·62	2·37	5·33	9·37	8·81	6·22	9·19
82·75	81·39	83·50	81·13	82·12	82·17	81·00	81·76	82·01	81·34
None.	Faint.	None.	None.	None.	None.	—	—	—	Medium
67·57	63·22	71·95	58·76	60·01	72·63	63·93	64·77	65·41	—

&c., Works, by the Chief Inspector, Mr. Alfred E. Fletcher.

TABLE No. II.—RESULTS OF

DESCRIPTION OF APPARATUS USED FOR FIRING.	HAND SPREAD. WM. AULD'S AIR BRIDGE.	THORNLIEBANK COKING STOKER.		
DESCRIPTION OF BOILER.	1 Lancashire Boiler, 7 ft. × 26 ft. 6 Galloway tubes in each flue.	1 Galloway Boiler, 7 ft. × 28 ft. 33 Galloway tubes.	1 Lancashire Boiler, 7 ft. 6 in. dia. × 28 ft. long. 6 Galloway tubes in each flue.	
Duration of Trial, - - - - Hrs.	10	10	10	10
Average Steam Pressure, . - Lbs.	35·75	62·1	63·2	60
Temperature of Feed Water, - °F.	135·2	48·9	48	43·2
,, Exit Gases, - °F.	407	633	705	731
Draught by W. G. at Boiler Damper, Ins.	0·55	0·60	0·51	0·56
Kind of Coal used, - - - - -	Earnock Triping.	Greenfield Virgin Dross.		
Coal used per hour, - - - Lbs.	694·4	918·4	939	952
Coal used per sq. ft. grate area, ,,	20·03	28·61	28·03	28·41
Percentage of Ash weighed, - -	9·67	13·62	12·97	17·92
Analysis of Coal, Carbon, - - - °/o	65·05	60·22	60·22	59·44
Hydrogen, - - ,,	4·49	4·40	4·40	3·86
Moisture, - - - ,,	7·66	10·20	10·20	7·56
Ash, - - - - ,,	9·70	13·18	13·18	14·79
Calorific Value, - . - B.T.U.	11,802	11,053	11,053	10,657
Carbon Value, - - - - Ratio	0·8116	0·760	0·760	0·733
Water evaporated per hour, - Lbs.	3554·5	6202	6151	5814
,, per lb. of Coal from and at 212° Fahr., - - ,,	5·63	8·1	7·86	7·35
,, per lb. Carbon Value from and at 212° Fahr., - ,,	6·93	10·65	10·34	10·02
Analysis of Gases of Combustion, Carbon Dioxide, °/o vol.	2·86	10·4	10·85	10·0
Carbon Oxide, ,,	—	—	—	—
Oxygen, - ,,	17·58	8·75	7·8	8·2
Nitrogen, - ,,	79·56	80·85	81·35	81·8
Smoke per hour, Dense, - - - - - Min.	None.	None.	None.	None.
Medium, - - - ,,	5	,,	,,	,,
Faint, - - - - ,,	40	,,	,,	,,
None, - - - - - -	15	,,	,,	,,
Percentage of Coal utilised in heating water, - - - - - -	46·16	70·77	68·74	66·62

Summary from Paper read to the Institution of Engineers and Shipbuilders

EVAPORATIVE TRIALS ON LAND BOILERS.

SINCLAIR'S COKING STOKER.	HAND SPREAD. ALTERNATE FURNACES.	VICARS'S COKING STOKER.		HAND FIRING.		HAND FIRING.			
				SPREAD ALTERNATE FURNACES.	ALTERNATE SIDE FIRING.	SPREAD FIRING IN ALTERNATE FURNACES.			
1 Lancashire Boiler, 7ft. 6in × 28ft 5 Galloway tubes in each flue.	1 Lancashire Boiler, 7ft. 9in × 26ft Cross tubes each flue.	1 Lancashire Boiler, 7 ft. 6 in. × 30 ft. 10 cross tubes in each flue.		1 Burnet's Dryback Tubular Boiler, 10 ft. dia. and 8 ft. long. Geddes' Fire-doors not built in.		1 Burnet's Dryback Tubular Boiler, 10 ft. dia. and 8 ft. long. Geddes' Fire-doors built in.			
10¼	8¾	8¼	8¼	7⅓	8⅙	8 h. 3 m.	9 h. 46 m.		
89·6	34·21	87·1	86·05	57·77	58·81	62·1	65·4		
135	175·72	44·07	42·5	141·25	143·18	137	130·6		
580	717	501	504	635	706·7	669·6	622·6		
0·60	0·2	1·5	1·44	0·26	0·29	0·6	0·45		
Douglas Park Colliery Dross.	Summerlee Main Dross.	⅓ Lanemark Splint. ⅔ Daldowie Main Dross.		Blantyre Special Dross.		Dykehead Ell Dross.	Monkland Ell Dross.		
631	880	1141·5	1230·4	450·6	551	787·2	560		
21·64	25·88	65·22	70·3	15·71	19·21	21·06	16·0		
19·04	10·55	16·5	15·86	11·36	7·36	10·06	8·06		
58·48	58·37	54·50	52·84	65·04	65·04	65·46	63·29		
4·49	3·05	3·80	3·52	4·25	4·25	4·26	4·43		
7·84	9·96	9·84	10·70	10·02	10·02	12·58	11·86		
16·54	19·24	20·20	21·00	6·61	6·61	8·70	10·10		
10,846	10,079	9,908	9,520	11,675	11,675	11,734	11,514		
0·746	0·693	0·6814	0·6547	0·803	0·803	0·807	0·792		
3501·46	5256·5	4929·5	5389	2703·4	3325·5	4874	3894		
6·2	6·33	5·23	5·30	6·62	6·65	6·85	7·75		
8·3	9·13	7·67	8·10	8·24	8·27	8·48	9·77		
6·22	9·45	3·4	5·59	5·50	7·53	7·30	8·47		
—	1·45	—	—	—	—	·40	—		
13·16	7·57	16·4	13·44	14·77	11·10	10·05	10·13		
80·62	81·53	80·2	80·97	79·73	81·37	82·25	81·40		
None. ” ” ”	No Observation.	None. ” ” ”	None. ” ” ”	At 10 and 2, when breaking up fires, 2 min. med. and 5 min. light, and 1 min. light smoke after charging fires.	At 10 and 2, when breaking up fires, 2 min. med. and 5 min. light, and 1½ min. light smoke after firing.	No Observation.	1½ 3½ 25½ 29½		
55·23	60·59	51·00	53·88	54·79	54·93	56·38	65·05		

on 18th December, 1894, by Geo. Carruthers Thomson, Consulting Engineer.

A mechanical stoker is often fitted to a boiler, in the belief that the emission of smoke will be prevented, and that at the same time a larger amount of work will be got out of the boiler. This is not always the case, however, as, if fitted to a boiler already large enough for the work, it will reduce smoke and waste caused by careless hand-firing, but, if applied to a boiler already too small for the work to be done, it will not give the increase of power expected and decrease the smoke, as the margin between skilful hand-firing and skilful mechanical stoking is so very small that it cannot be reckoned upon, and this is the cause of the dissatisfaction so often expressed when mechanical stokers have been used with the expectation of increased power and smokelessness.

It is only to be expected that an apparatus which suits for the combustion of a free-burning, non-caking, bituminous coal, without emitting smoke, will not suit for using with a slow-burning, caking, bituminous coal, if the remaining conditions are identical, but that considerable alterations would be necessary to attain the same result. From the results given in Table No. II., it is shown that a Lancashire boiler, 7 ft. 6 in. diameter and 28 or 30 ft. long, with ample and well-constructed flues and chimneys, and a draught of ½ inch by water gauge, can evaporate from 6,000 to 7,000 lbs. of water per hour, and that each pound of coal as usually employed can evaporate from 6 to 7½ lbs. of water in regular work, by either hand or mechanical firing, and without emitting visible smoke from the chimney, save for a few minutes when breaking up fires after stoppage for meals.

When doing this amount of work, from 55 to 65 per cent. of the heating value of the fuel is returned to the factory owner in the form of steam; and by the exercise of care and supervision in the firing of the boiler, and keeping the flues clean, an extra 5 per cent. may be obtained—the remainder going to heat the air required for combustion of the coal, evaporating moisture in fuel, loss by radiation, &c., &c.

Coal is also used in the form of a fine powder or dust, and requires special treatment and furnaces specially constructed to burn it, and where this is the case, and ordinary care is used, there is no smoke emission from the chimney. There is, however, but a very small proportion of the fuel in this country burned in this form, and there are several patented methods of doing so efficiently.

The use of coal gas as fuel in furnaces has been strongly advocated by various eminent scientists and engineers and has

been largely used in the steel industry—for example, where very high temperatures are employed; and, in some cases, gas has been used in boiler furnaces, but its use is far from general. For the manufacture of this gas special forms of kilns or stills are necessary, and the best-known types are called Siemens, Wilson, or Thwaite gas producers, and the resulting gas is known as "producer gas." From some cause or other, the various attempts to use such gas for boiler furnaces have not proved a practical success in the long run. There is no doubt that boilers can be fired with producer gas economically and under the perfect control of the fireman, and maintain a constant pressure of steam while emitting no smoke, but it must not be forgotten that quite as much care must be exercised in this system as in any other, if the desired results are to be obtained.

The use of mineral oils as fuels has also been prominently before steam users, but, save in a few isolated cases, has not been taken advantage of in this country. It may be that the cost is more than when using coal, and it is certain that fully as much skill and care must be exercised when burning oil as when using coal, if satisfactory results are to be attained.

The use of forced blast, or intensifying the draught by mechanical means, is also held up in many cases as a remedy for smoke nuisance, but, as with coal dust, gas, and oil, when the use is not directed by skill, intelligence, and judgment, the result is smoke emission far in excess, as a rule, of anything in the power of an ordinary hand fireman.

In a paper read before the Institution of Engineers and Shipbuilders in Scotland in 1888, I gave a resumé of the results obtained by most of the methods hitherto enumerated.

Let us now look at the actual results that have been obtained in the evaporation of water while making no smoke emissions, as given in Tables Nos. I. and II. In No. I. Table the boilers generally have been larger than those tested in Table No. II., and have all had economisers attached; and the quality of the fuel has also been higher, while the evaporation per lb. of fuel from and at the standard temperature of 212° Fahr. ranges from 7¼ lbs. to 9 lbs. of water, and in No. II. Table they only range from 5¼ lbs. to 8·1 lbs., with no economisers attached—a very considerable difference.

In the first column of No. II. Table the evaporation was greatly reduced by too large a quantity of air being admitted at the bridge,

being about seven times what theory demanded. In the three following trials the air supply ranged from $1\frac{5}{8}$ to twice the theoretical supply, and the different amount of water evaporated per lb. of fuel is very marked. In the sixth column the draught was affected by small and crooked flues and too small a chimney, but by careful firing a very fair result has been obtained. In the two tests with Vicars's stokers the percentage of air was five times the theoretical amount, and in the second it was reduced to 3·13 times what theory demanded, with increased duty from the boiler, though using inferior fuel. The draught in this case is higher than in many cases where forced draught is employed. The two columns following, of hand-firing, as applied to Burnet's dry-back boiler, give very fair results, but the grate surface was too large for the work demanded of the boiler, and would have given higher results with a shorter grate.

In the two last columns the firing was similar, but, the boiler being over-taxed for work in the first trial, the results per lb. of fuel are lower than in the following trial, when the boiler was working much nearer to its best rate of working for all-round efficiency.

These trials show what can be obtained under every-day conditions, and I am not overstating by saying that the average results obtained all over the city and neighbourhood fall short by 10 to 15 per cent. of what is given in these tables. I leave it to you to calculate the difference it would make in the coal bill at the close of the year, if a little more care and supervision were exercised in the boiler-firing department.

As showing the influence of the fireman on the efficiency of the boiler, the following results may be of interest:—

M. Burnat, at Mulhouse, in 1861, tested the work of 8 firemen on Dollfus-Mieg's boiler of 1859, and found that the efficiency was diminished as the weight of the charge increased, and that there was a variation of 14 per cent. caused by the variety of management. In 1875 he tested the work of 10 firemen on new boilers in the same factory, and found a variation of 10 per cent. in the efficiency of performance. He also considered that a skilful fireman might save one-fourth of the coal consumed by an unskilful or negligent stoker.

It is unnecessary for me to go into the question of which is the best machine or apparatus to attach to the boiler, as each case must be considered with regard to its requirements and the surrounding

conditions. On the walls are shown drawings of some well-known apparatus, and the technical journals teem with apparatus whose makers claim them to be superior to all others under all circumstances, while the steam user, after trying several, generally falls back in disgust on the despised hand-fireman, with all his imperfections, as being the one which gives him least annoyance.

In some parts there is a belief that, if the black smoke were done away with and the chimney-tops were clear, we would all be poisoned by the deadly fumes of carbon monoxide gas. To combat this view, and prove the baselessness of these fears, Mr. Alfred E. Fletcher, the Chief Inspector under the Alkali Act, carried out a large number of tests on the gases from boiler furnaces fitted with a great variety of apparatus, and has given the results in the 25th and 29th Annual Reports to the Local Government Board. An examination of these shows that while in some cases where black smoke is emitted carbon monoxide is present, when the chimney-top was clear no traces of this gas were found.

It is often said that a very great amount of fuel is wasted and disappears in the form of black smoke, but it appears that this amount is much less than is generally supposed. Scheurer-Kestner, in his experiments at Thann in 1868, found that the amount of carbon passing away as soot in the smoke varied from ½ to 1 per cent. of the carbon in the coal. Later, in the *Rev. Scient.* of 18th February, 1888, he mentions that he found the loss when a thick black smoke was made to be 1½ per cent., which was reduced to ½ per cent. by the admission of more air.

R. Irvine, in a paper on the "Condensation of Carbon Particles in Smoke," read before the Society of Chemical Industry in 1891, estimates the amount of soot as 3 per cent. of the whole smoke.

Messrs. Cohen & Hefford (*Journ. Soc. Chem. Ind.*, 1893, p. 122), calculating from the results of Roberts-Austen's experiments given in the report to the Smoke Abatement Exhibition of 1881 and 1882, and also from their own experiments, find a mean of 5 per cent. of the fuel burned is left behind as soot.

They reckon that in Leeds, with a household consumption of 100,000 tons per annum, 5,000 tons yearly, or 7 tons per 12 hours, pass up the chimney as soot.

R. R. Tatlock, in a paper on the "Heating Power of Smoke" (*Chem. News*, 70, p. 51, 1894), states that the loss of heating power by the carbon passing away as soot in the smoke only

amounts to 1·83 per cent. of the volatile portion of the coal, or only 0·74 per cent. of the practical heating power of the coal used in the case recorded, and the smoke was quite black.

According to O. Gruner (*Civiling*, 1892, p. 565), the fires in Dresden deposit about 4,800 cbm. or nearly 1,000 tons soot, equal to 20 kg. soot daily on each qkm., or ·069 oz. per square yard; while in Manchester, in foggy weather, it has been observed that within three days the fall of soot amounted to 256 kg. per 1 qkm., or ·351 oz. per square yard. I am not aware what the amount for Glasgow may be, but it cannot be much behind that of Manchester in this respect.

On the 3rd of February, 1892, Dr. W. Ernest F. Thomson read a paper before this Society on "Fogs: a review of our present position regarding them," in which he gave a very lucid description of their origin and effects, quoting largely from the researches of Mr. John Aitken, F.R.S. :—

"If we could get fuel without sulphur, we should get rid of a powerful element in the production of our city fogs, for, as I shall presently point out, Mr. Aitken has proved that sulphurous gases are powerful fog-producers. We should not, it is true, get rid of the nuisance entirely; but consider how comparatively cheerful and country-like would be a Glasgow fog without its characteristic 'blacks' and its characteristic odour.

"Very much has been said in the past about soot as the cause of fog, but I think that these experiments have made it clear that the sulphur compounds, rather than the soot, are to blame. The 'blacks' must act as condensation nuclei to some extent, but they fall, owing to their weight; while the smaller sulphurous particles, with their coating of water, are infinitely more numerous, and, being light, remain suspended in the air.

"There are several ways in which foggy weather may be prejudicial to human life apart from the actual cold :—

"1. By the irritating action of the sulphur compounds and soot on the respiratory passages.

"2. By the withdrawal of light from our daily life, and corresponding mental depression.

"3. Possibly by the poisonous effects of sewer emanations carried down from the ventilating shafts of sewers. These emanations have been said to cause 'fog diarrhœa.'

"4. By the substitution of carbonic acid for some of the oxygen. It is said that in still, foggy weather the carbonic acid from the chimney tops falls owing to its high density, and mixes in undue proportion with the air next the ground."

Siegfried Hamburger, in a paper on the "Injury to Vegetation from certain Manufacturing Operations" (*Journ. Soc. Chem. Ind.*, 1884, pp. 203-343), quotes the following from Dr. Angus Smith:—"In a part of London where coal is, in the main, only used for domestic purposes, he found 730 grains SO_3 in 1,000,000 cubic feet air. In Manchester, an industrial town, he found 1,098 grains. Hamburger found in St. Helens 1,260 grains in the same amount.

"Mr. Fletcher (1879) calculates that the gases escaping into the air at St. Helens per week contain:—

"Fire gases,	800 tons SO_2.
Copper works,	380 ,, ,,
Glass works,	180 ,, ,,
Alkali works,	25 ,, HCl."

These extracts show some of the bad effects of coal smoke when combined with fogs; but we have not always foggy weather, and still we find that the trees, plants, and flowers in our parks and gardens will not thrive, and this must be owing, in the main, to the presence of the sulphur compounds and soot in the air, and to the scanty supply of sunlight which they receive, on account of the veil of smoke which is seldom absent, and floats over our great city.

We have only to look at the difference in the number of the trees and their appearance in the Glasgow Green, Kelvingrove Park, and Botanic Gardens, to note the difference; and our late Superintendent of Parks, Mr. M'Lellan, in one of his letters to the newspapers on plant life in our cities, has given a list of the plants which are best qualified to survive the ordeal of existence in our smoke-polluted atmosphere.

There are many other ways in which the deleterious effect of black coal smoke can be observed, and telegraph engineers, I have no doubt, could tell us how the insulation and life of their wires are affected in different districts where smoke is practically the sole cause of this difference.

Those who have had the good fortune to reside in a town where the fuel used is wood will know the difference of the atmosphere during a fog, which, in such a case, is clean and light compared

with that which we are accustomed to in Glasgow, and is almost as clean as the mist on the hill-sides.

The loss to the people in extra lighting, washing, &c., caused by the darkness of the pall of smoke, especially when coupled with fog, must be very great, and I shall not attempt to estimate its amount, but I know our gas managers have a busy time of it in foggy weather, and especially so when it comes on them suddenly.

These remarks show that there is need for abating the nuisance of coal smoke, if we are ever to hope that Glasgow may see plants and flowers thriving in the parks and gardens, and if the back-greens are ever to regain a right to their name by the green grass growing abundantly, to refresh the eye, where now only a blackened and disfigured vegetation is seen, and called grass by courtesy.

It is evident from the foregoing that there is pressing need for active steps being taken to abate the smoke nuisance, but the question how this may be effected is not quite easy of settlement. We have seen that stringent laws for its suppression, both at home and abroad, have failed in attaining the desired result, owing to the apathy of the smoke-producers, and the laxity with which these various laws have been administered.

The problem of dealing with the visible constituents is one that is capable of being dealt with by care and skill as to the manner of consuming the coal; but when we turn to the invisible constituents a greater difficulty appears, and it is vain to advocate the use of gas, as that would not get rid of the sulphurous acid unless it were filtered so carefully that all the acid might be kept back. It has been proposed to collect all the gases from the various works and dwelling-houses, and conduct them to central depots, where all the deleterious matters and gases would be retained and made use of, and it is expected that the carrying out of this idea would yield handsome dividends in return for the sale of the products. A very slight consideration of the facts that I have laid before you will show that these expectations are fallacious so far as financial matters are concerned, although there is no doubt of the effect it would have in clearing the atmosphere were the scheme carried out.

Under the Alkali Act, the inspectors have no power to deal with the sulphurous acid given off in the combustion of coal, while they can deal with it from any other chemical process; and they sometimes find that a larger quantity of sulphuric anhydride

escapes from coal combustion than what is allowed to escape from sulphuric acid works.

My own view is that the operations of the Alkali Act should be extended to embrace the combustion of coal for industrial purposes, which would require additional inspectors; or that a special Act, and inspectors with similar powers to those contained in the Alkali Act, be passed, dealing with the industrial uses of coal alone, and which could afterwards be extended to embrace the domestic use of fuel as soon as the public voice demanded. The inspectors would require to be capable of dealing with the subject both from the practical and the scientific points of view, and have the power to visit any work or factory at any time, so that they might judge how best to deal with each case as it arose, and to have power to institute prosecutions where other means of bringing the owners to abate the nuisance had failed. I believe, if such an arrangement were carried out, that it would meet with the approval of all concerned, and also meet the wishes of the public. I am strengthened in this belief by the utterances of manufacturers before various learned and technical societies, by statements of the benefits conferred by the operations of the Alkali Act, and contained in the reports of the Chief Inspector, and also by what I have been told by manufacturers in all branches of trade in this district. I am sanguine enough to believe that this would reduce the nuisance to such an extent that no one could complain, and also that it could be attained with only a very small percentage of the annoyance and prosecutions which at present, and for a considerable number of years, have taken place.

I shall now close, trusting that I have been able to give you some information which may assist you to bring about a smokeless Glasgow without destroying the industries by which it exists.

XI. — *The Anti-toxin Treatment of Diphtheria.* By John Glaister, M.D., D.P.H.(Camb.), &c., Professor of Forensic Medicine and Public Health, Saint Mungo's College, Glasgow.

[Read before the Society, 20th March, 1895.]

There is probably no department of the science of medicine which has made more rapid and enormous advances during the last twenty-five years than that which has been named Preventive Medicine. This branch may be sub-divided into several sub-branches, all of which, working on different lines, and in different fields, have one common characteristic—namely, the discovery of the more occult processes of nature, whereby the health of man is affected.

While much has been done by general hygiene to remove and modify many factors which operate prejudicially upon the health of people in the mass, much has also been done in one special branch of preventive medicine—namely, in the bacteriological,—in the pursuit of those causes which produce infectious diseases, which pursuit has been rendered more successful by the use of the microscope in its higher powers, and by the use of culture fluids in which the different micro-organisms may be sown, grown, and multiplied.

Microbes—literally, small living things—are to be found everywhere in nature—in air, earth, water, within and without our bodies. They operate in curious ways and in divers places, conservatively and destructively, and are both the friend and the foe of man. They rid the earth of dead and decaying matter; they form new chemical compounds in the course of these operations; in their grosser and fungoid forms, they produce the alcoholic fermentation in suitable liquids; they make our sweet milk turn sour, our butter to become rancid, our bread to become mouldy; and perhaps the most serious action which they produce is to be found in a large number of the diseases of man and animals, while, in addition, they are the prime movers in the causation of all

zymotic or infectious diseases of animals—man included,—in which connection they have been called microzymes, or small ferments, from their supposed mode of action.

A knowledge of them is of importance, alike to the agriculturist, the horticulturist, the physician, the surgeon, and the hygienist;—to the two first, in respect of their being the cause of many of our crop-blights, our potato-disease, vine-disease, and the various infectious diseases of animals; to the physician, in being the cause of many obscure diseases as well as the whole range of zymotic diseases; to the surgeon, in respect of their being the cause of putridity in wounds and of septicæmia; and to the hygienist, in respect that a knowledge of them and their life-histories is contributory to success in their prevention or the amelioration of their evil effects.

The evolution of time has brought about the closer study of those micro-organisms, concerning the very existence of which so much controversy has raged within the last twenty-five years, with the result that their existence is not only incontestably proved, but their isolation, their culture, and their actions have become historical achievements. It is too late in the day to doubt or deny their presence; it is still open, however, regarding several of them, to speculate as to their action.

This Society, by its Sanitary Section, has always been keenly alive to the advancements of Preventive Medicine. One of its former Presidents—the late Dr. Andrew Fergus—did much in his papers to instruct the members and the general public regarding the evil effects of sewer-air and sewer-gas. Probably their effects were then over-estimated, and the effect of the study of their influences on health, which he did much to initiate, has been to relegate them to better-defined lines of action. This paper is an attempt to follow on the lines of the policy of the Society.

The attention which has been given of late years to the study of Preventive Medicine is already bearing fruit; every decade points to lowered general death-rates in populous communities; some diseases are well-nigh extinct; people are enabled to live more comfortably and to live longer. But after this has been said, much remains to be done. Although typhus is now a rare disease in Glasgow, where it once was a plague, enteric fever and other scourges still remain. These so-called preventable diseases are, in many cases, still unprevented, although it is undoubted that, year by year, we are realising the query of the Prince of Wales in his

opening remarks at the Hygiene Congress in London: "*Then, if preventable, why not prevented?*"

This leads me to say, briefly, what has been done in recent times in this regard, chiefly however, by Continental workers. Pasteur, by his researches into the cause of Anthrax—a disease of cattle and sheep,—has not only been able to track the bacillus or microbe of the disease, but he has also been able to produce a vaccine, which, injected into the bodies of unaffected animals, prevents the disease doing them harm. From this discovery alone, hundreds of thousands of pounds have been saved to the agriculturists and to the nation of France. His researches on Rabies are now known over the world, and even from Glasgow we are at this time of day compelled to send persons bitten by rabid animals to his Institute at Paris for treatment. Here, curiously enough, although the microbe of the disease has not yet been isolated, Pasteur, in 1884, was able to produce a successful form of treatment against the operation of the disease in the person affected. So, likewise, from the study of Glanders in horses—a disease which is communicable to man, and which is often fatal,—not only has the bacillus been discovered, but its active principle has now been isolated, and is being used to-day in the diagnosis of obscure cases of the disease; that is to say, by injecting into the body of a horse some of this *Mallein*, an answer can be definitely given as to whether or not the animal suffers from the disease. Thus, a diagnostic power of great value has been placed in the hands of the veterinarian. So also, from the study of Tuberculosis by Koch, we have obtained *Tuberculin*, which, although it proved a disastrous failure as a curative agent in consumption, is proving of great value in the diagnosis of the latent tuberculosis of cattle.

In addition to these, patient and painstaking research has resulted in the discovery of the microbe of Cholera by Koch, of the microbe of Enteric Fever by Eberth and Klebs, of the micrococcus of Measles by Batés, in 1880; of the microbe of Pneumonia by Friedlander and Talamon, in 1882; of the microbes of Erysipelas, of Scarlet Fever, of Tetanus, of Leprosy, and of Influenza; and of the bacillus of Diphtheria by Klebs, in 1873, and afterwards confirmed by Lœffler.

We have here, then, abundant illustration of the magnificent work which has been, and still is being, performed in the department of bacteriology. Our concern, to-night, however, is with the microbe of Diphtheria, a disease which is wide-spread, which

has been universally dreaded because of its great mortality, but to which recent investigation has apparently produced an antidote.

STEPS LEADING TO THE DISCOVERY OF THE *BACILLUS DIPHTHERIÆ.*

Laycock,* in Great Britain, was probably the first observer who associated Diphtheria with a micro-organism; but his idea of the character of this microbe was very wide of the mark. This was in 1858. On the other hand, in the Report of the Committee on Membranous Croup and Diphtheria, appointed by the Royal Medical and Chirurgical Society in 1879, to investigate the etiology of these diseases, we find the Committee reporting that, while they admitted that different micro-organisms were found at one and the same time in the false membrane of Diphtheria, they did not associate them as being the causative agents of the disease. Then Oertel in Germany, finding a streptococcus in the membrane very constantly, believed that *it* was the etiological factor. Klebs next discovered a bacillus in the throat, which he described, but failed to isolate. It was not, however, till Friedrich Lœffler set about the investigation of the disease that the bacillus which Klebs described was isolated and grown, and which is now proved to have the relation to the disease of cause and effect. During the investigation, however, besides this bacillus, Lœffler came upon this chain-forming microbe already spoken of, and at first he was not certain whether this form or the rod-like form, or both, were the causal factors. Experiments on the lines laid down by Koch quickly settled this question, and now we know the *bacillus diphtheriæ* as the Klebs-Lœffler bacillus.

In the isolation and cultivation of these microbes, it is of interest to know that one of the modes by which they may be differentiated is by their preference for, or susceptibility to, certain dye-stains. The *bacillus diphtheriæ* is very susceptible to the dye known as methylene blue, one of the aniline colours, made up in certain proportions with alcohol and solution of potash—namely, 30cc. of concentrated alcohol solution of methylene blue to 100cc. of (1 in 10,000 of water) solution of potash. The tissue supposed to contain these bacilli is placed for a few minutes in this solution, then placed in a half per cent. solution of acetic acid, and next dehydrated in alcohol, and immersed in cedar oil and mounted.

* *Medical Times and Gazette*, May 29*th*, 1858.

Lœffler, too, found when making cultures of the bacillus that the nutrient jelly of Koch was not suitable for its growth, although quite suitable for the other form of microbe. He discovered that it grew best in *coagulated blood serum,* made up of three parts of the blood serum of the calf or lamb, and one part of veal solution, containing one per cent. of peptone, one per cent. of grape sugar, and a half per cent. of common salt.*

What are the characters of the *bacillus diphtheriæ*? Although the microbes may vary slightly in length, the average is from a quarter to half the diameter of a red blood corpuscle—that is to say, from ·0015 to ·0035 of a millimetre, and they are either straight or slightly curved, and somewhat thickened at one extremity. They are non-motile. They require for their cultivation and growth a temperature above 68° Fah. (20° C.), and they are destroyed by exposure for half-an-hour to a temperature of 140° Fah. (60° C.). Their average life in the most suitable environment is about three months.

In his experiments to test their casual relationship to the disease, Lœffler discovered the very interesting fact, that all animals were not equally susceptible to their evil influence. The following animals, and in the following order, showed increasing susceptibility:—hens and pigeons, small birds, guinea-pigs. The last named were quickly affected, while rats and mice were quite insusceptible.

The next point of interest to make clear is, in what part of the body of the person affected with diphtheria are these bacilli found? Let me answer this by saying where they are not found, namely, in the blood of the person attacked. They are always to be found, however, in the patches of deposit or false membrane, as it is termed, which are to be seen in the throat or air-passages, grouped in masses. They are invariably situated near the surface of the false membrane, for they require air for their growth; they are aerobic. But what causes the constitutional symptoms of the disease, namely, the fever, the prostration, and the occasional after-coming paralysis? The bacilli during the act of growth, and as the direct result of that growth, in using up the nutrient material which they find in the fluids of the throat and its tissues, create

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**Mittheilungen aus dem K. Gesundheitsamte,* Vol. II., Berlin, 1884. *Vide* also "Micro-parasites in Disease," New Sydenham Society, 1886, pp. 448, *et seq.*

new chemical substances of a poisonous or toxic character, called albumoses or toxines. These toxines, so formed, are absorbed into the blood of the person, and there give rise to the above-mentioned grave symptoms. Hence it is that, while the manufacturers of the poison or toxine live practically on the surface of the body, the toxine itself is introduced into the blood by absorption. Obviously, then, to overcome the constitutional effects of this toxine is to cure the disease; and hence the treatment has been termed the "anti-toxin" treatment.

We have now reached this stage of discovery—namely (1) that a bacillus, distinct in character and effect, is the causal factor in the production of the disease; (2) that this bacillus can be isolated from the deposit upon the throat of a diphtheritic patient; (3) that it can be artificially cultivated outside of the body; and (4) that this artificial culture, or even a part of it, when injected into the body of a healthy animal, will produce both the physical and the constitutional signs of diphtheria. But, it may be asked, how came about the discovery of the principle of the sero-therapeutic treatment? It had already been established by several observers that if the microbes of certain well-defined diseases—anthrax and others—were cultivated out of the body, and their original virulence weakened, and if such attenuated viri were injected into the bodies of sound animals, such animals would not become the subjects of the virulent form of the disease; that is to say, they had become protected; and the experience of the last hundred years in our own country has abundantly shown and proved the protecting influence which vaccinia imparts against smallpox.

In this connection various Continental observers had been doing splendid work. Babès, of Buda-Pesth, with Lepp, in July, 1889, had established this principle in respect of the treatment of hydrophobia,* and Behring and Kitasato had published in 1890 an article on the immunisation of animals against tetanus;† but the credit of the application of the principle to the treatment of diphtheria must be given to Professor Jaime Ferrán, of Barcelona, who, in a communication to a Spanish journal, of date April, 1890, pointed out and described a safe and practical method of immunising animals against fatal doses of diphtheritic poison, which he himself had successfully employed.

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* *Annales de l'Institut Pasteur*, July, 1889.

† *Deutsche Medicinische Wochenschrift*, No. 49, 1890.

From animals to man is but a short step; and to Behring, of Berlin, must be ascribed the honour of applying the principle to man. Before this, however, Roux and Yersin, of the Pasteur Institute, had been able to demonstrate that the bacillus of this disease was capable of evolving toxic material.

If I were to summarise the points which led up to this stage, I would put them thus:—

(1) Lœffler and Klebs discovered the bacillus, studied its life-history, and proved it to be the causal factor in the production of the disease;

(2) Roux and Yersin demonstrated that during its growth it manufactured a toxic substance which produced the constitutional disturbances in the person or animal affected; and

(3) Behring manufactured the anti-toxin.

As Roux himself has expressed it, "Behring, therefore, has completed and crowned the edifice."*

The terms "protection," "immunisation," and "immunity," having already in the course of this paper been more than once mentioned, it behoves that I should explain what they mean.

What is Immunity?

Necessarily, the answer to this question must be somewhat speculative, but the speculation is limited by the knowledge we possess of certain phenomena observed in cases of infectious diseases. In the first place, we know that if an individual is seized with an infectious disease and recovers from the illness, most usually (for there are certain odd exceptions even in this) a re-exposure to the infection of the same disease will not affect him. We then say of this individual that he is *protected* against a subsequent attack of the disease by reason of this first attack; or, in other words, he is *immune*. If we take the whole range of infectious diseases, we shall find that, in certain of them, the immunity conferred by an attack is more enduring—that is to say, it covers a much longer period of time—than in others. This is not relative to the particular individual only, but is in the nature of the contagium itself.

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* *British Medical Journal,* Vol. II, 1894, p. 931.

Knowing these facts, we have still to satisfy ourselves how this degree of resisting power is conferred on the individual. By what physiological process is it produced? And this is where the speculative element or theory comes in. We at least can say this, that the resistance is the sum of the effects of the introduction, growth, multiplication, and death of the living micro-organisms in the body during the currency of the illness, whether the illness be induced naturally or experimentally. But the intimate cause of the immunity or resistance we cannot tell. Various theories, however, have been propounded on this subject; among others, by Klebs, Pasteur, Chauveau, Wernich, Grawitz, Buchner, and Wolffberg, but I do not stop to discuss these. We do know that if we take the blood of an animal which has survived an attack of an infectious disease, it will prove antagonistic to the blood of another animal which is at the time suffering from the same disease; in other words, it exercises an antidotal or anti-toxic influence over the toxic blood of the second animal. So also, is it true that, *ab initio*, certain animals are more easily rendered immune than others.

Starting, then, from the known fact that the blood of an animal which has successfully passed through an attack of an infectious disease is antagonistic to the poison in the blood of an animal suffering from the same disease, it makes no difference whether the disease has been acquired naturally by, or has been conferred artificially upon, the animal. As has already been pointed out, the blood of the first animal is antidotal to the poison in the blood of the second; or, in other words, the one is anti-toxic to the other, and the material which has this anti-toxic character may be called anti-toxin.

HOW IS THE ANTI-TOXIN OF DIPHTHERIA PREPARED?

There are two main methods employed in the preparation of the anti-toxin serum:—

(1) By injecting the toxines produced in the growth of the bacilli into the body of an animal in doses of gradually increasing strength; and

(2) By injecting attenuated bacilli—that is to say, bacilli of lessened virulency,—together with their toxines, into the body of an animal, in doses made gradually stronger.

The aim and object of the treatment, in either case, is to accomplish the complete immunisation of the animal, so that its blood will be thoroughly antagonistic to the toxines circulating in the blood of an animal actually affected. The first method is that employed by Behring, and afterwards by Roux, Ruffer, and others; the second by Klein, in his recent investigations at the instance of the Local Government Board.

They deserve some detailed consideration. In the *Annales de l'Institut Pasteur* for September, 1894, Roux's method is described as follows:—

The bacilli taken from a typical case of diphtheria are cultivated in a suitable culture medium. This culture is inoculated into a sterilised alkaline beef-broth, containing a half-per-cent. solution of common salt, and two per cent. of peptone, in a flat-bottomed flask, corked with a two-holed indiarubber stopper, each hole of which carries a glass tube, one acting as an inlet, the other as an outlet, while air is being aspirated through the flask. Soon after the bacilli begin to grow in the beef-broth, which has been heated to a temperature of 37°·C (98·6 Fah.), a current of moist air is drawn through the flask and over its contents by means of the glass tubes, and a flocculent deposit begins to fall to the bottom of the fluid, and which continues to fall for some time. At the end of a month the clear supernatant fluid in the flask, which contains the toxine, is filtered through a Pasteur-Chamberland filter, which permits the fluid containing the toxine to pass through, but retains the bacilli. This toxine is now sufficiently strong that 0·1cc. (one-tenth) will kill a guinea-pig, weighing 500 grammes (about $1\frac{1}{10}$ lbs.), in 48 hours, and it is ready for use on the horse.

The horse is now preferred for the preparation of the anti-toxin—first, because it has but small original susceptibility to diphtheria; and, second, because it can yield large quantities of its blood without suffering inconvenience. In an earlier stage of the experimental inquiry, however, the blood or serum of goats was used. A healthy horse having been chosen, which has been proved to be clear of any taint of tuberculosis or glanders by the injection of tuberculin and mallein, it is ready for treatment.

Into the animal are injected, at first small, then progressively larger, doses of this toxine, the effects being observed in the swelling produced at the seat of puncture (Roux prefers the front of

the shoulder), and in the rise of the animal's temperature, which symptoms are allowed to subside before the next injection—the quantity of toxine used at first being 1cc., rising gradually until the animal can bear with impunity a dose of 200cc. The period of time covered before the animal is completely immune is about three months (72 days).

Let us pause a moment to note what has happened in the blood of the horse as a consequence of the foregoing treatment. In the first place, the toxine was produced in the flask as the effect of the growth of the living organism; this toxine has been injected in increasing doses into the animal's body until the point is reached when the animal is absolutely invulnerable to diphtheria. During this period each succeeding injection confers on the animal a degree of toleration of the toxine, and this degree of toleration rises as the doses increase in quantity, or, in other words, the blood-serum has attained the power of neutralising, has become antagonistic to, the toxine injected—that is to say, the blood is now anti-toxic to the toxine. To prove this is simple. If some of the serum from the blood of the animal be placed in a tube containing some of this original toxine, the combined liquid injected into the body of a susceptible guinea-pig would not produce any effect; the one has neutralised, or destroyed, the virulency of the other.

We have, however, only attained this important fact—namely, that the blood of this particular horse is, to a certain undefined degree, antagonistic or anti-toxic to the poison or toxine produced by the growth of the bacillus. Obviously, it will be of the utmost importance that its exact potency be known, in order that we may learn what quantity of it to inject into a human body. To obtain this knowledge the serum must be tested against toxines of known potency; as the chemist would say, it must be "standardised." To accomplish this, we again call the lower animals to our aid, and we choose the guinea-pig. The mode of "standardising" now adopted is that which is known as Ehrlich's method. This method is very exact. Taking a guinea-pig about 500 grammes in weight, it is first ascertained what quantity of toxine will prove fatal to the animal. This gives a definite point from which to begin. Then by mixing a definite amount of this toxine with definitely graduated quantities of the horse-serum procured as already described, the precise point of dilution at which the serum proves completely antagonistic to the toxine is discovered.

This is shown by the harmless effect produced by the injection of the mixed liquids into the guinea-pig.

Let me illustrate this point further. Suppose that ten times the dose of toxine necessary to kill a guinea-pig be mixed in one solution with one-third its quantity of the anti-toxin blood-serum; in a second solution, with the same amount of toxine, but with one-quarter its amount of serum; in a third with one-fifth; in a fourth with one-sixth; and in a fifth with one-tenth. It will be obvious that the poisonous or toxic effect of the original toxine will be modified by the anti-toxic horse-serum in each of the series of admixtures in direct ratio to the anti-toxic potency of the blood-serum. By how much the toxine is overpowered by the serum is shown after one injection of each of the series of solutions into the bodies of guinea-pigs, by the symptoms which are produced in the animals afterwards,—these symptoms being the inflammatory tumour at the seat of injection and the rise of temperature. By this means the point or degree of dilution (and hence the degree of potency of the serum) is reached at which the toxine is rendered inert—that is to say, the point at which the serum (or anti-toxin) has completely neutralised the toxine. It has been found that the serum of a horse treated as described has an anti-toxic potency from fifty to one hundred times greater than the serum of an untreated horse.

A quicker way, but one less exact, is to inject into the body of a guinea-pig ·01cc. of the horse-serum, and in 24 hours thereafter injecting 0·5cc. of a virulent culture of the living bacillus—a quantity which would prove fatal to an unprotected animal. Should the guinea-pig exhibit no evil effects, then at once it is known that the horse-serum is sufficiently powerful for use in the human subject.

The serum is obtained from the horse after treatment by tapping the jugular vein with a sterilised instrument. The blood is collected in sterilised glass jars, which are then either kept air-tight, or into which are placed small chunks of camphor. Very quickly the blood separates into two layers—the lower being the clot, and the upper the serum, which is of a pale straw colour. After the clot has firmed, the serum is drained off into other sterilised bottles, after which it is "standardised" in the manner already described.

The principal objection which has been offered to this mode of preparing the anti-toxin according to Roux's method is the long

period of time which it demands, and Klein has been the first to raise this objection.* But in stating it, he does not mean to imply that the serum prepared by Roux does not correspond to the value which Roux attaches to it; on the contrary, he believes it has all that value, but he further believes that it is prepared at a needless expenditure of time, and, it may be added, with needless expenditure of the vital energy of the horse. Neither of these objections is of prime importance so long as the preparation is not a matter of urgency, since the animal is being well cared for during the process.

Klein's argument, to put it in his own words, is as follows:—"Roux," he says, "introduces over and over again large amounts of pure diphtheria toxine into a horse which has already, by previous injections of the pure toxine, been rendered to a certain extent resistant against this toxine (it is because of this resistance that he finds it necessary to increase the dose of the toxine)—that is to say, a horse that has, by previous injections of diphtheria toxine, become more or less resistant, must possess a corresponding amount of anti-toxine in its blood. But, since the two substances—namely, toxine and anti-toxine—are antagonistic and neutralise one another, it follows that each successive injection of a large quantity of pure diphtheria toxine into a given horse must neutralise a proportionate amount of anti-toxine already formed and in the blood of the animal. This possibly explains," he concludes, "the extraordinarily long time which Roux's horses take before their blood is rendered sufficiently anti-toxic."

This consideration led Klein to adopt a different plan, by which he claims to be able to manufacture the anti-toxin in a much shorter time. This plan differs from that of Behring and Roux in that, whereas these experimenters use in their injections pure toxine only, Klein uses attenuated bacilli—that is to say, bacilli whose virulency is lessened by their age—plus the toxine. Beginning in this way, Klein proceeds to inject more virulent bacilli (minus their toxine, however) as the animal becomes acclimatised, until it becomes completely immunised, observing intervals to enable the animal to recover after each injection. From this mode of treatment Klein has obtained potent anti-toxin at the end of 23 to 26 days. When the animal is bled to supply serum, two or three fresh injections keep the anti-toxic value of the serum up to the

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* *British Medical Journal*, Vol. II., 1894, p. 1,393.

mark. The potency of this serum is such that *one* part of serum is capable of protecting 20,000 to 40,000 grammes body-weight of guinea-pig against not merely pure toxine, but against living bacilli and toxine combined. This serum has frequently been used with success, the dose being from $1\frac{1}{4}$ to 2 drachms (5 to 10cc.).

This is not the time nor the place to describe the operation required for the application of the treatment; neither is it proper that cases of the disease subjected to the treatment should be here described. But, in general, it may be said that the operation itself is neither difficult nor dangerous, nor is the amount of pain accompanying it more than that caused by the prick of a sharp needle; further, it may be added, that it has proved successful in the very limited number of cases in which I have used it; and if the figures which I have to put before you are trustworthy—and there are no apparent grounds for any other belief—it promises to enable us to overcome not a little of the fatality of the past. One other remark on this point which requires to be made, is that the serum ought to be used as soon as the disease is known to be diphtheria. Not a little harm has been done, in my opinion, by waiting until other remedies have failed, by which time certain pathological changes have taken place in the body of the patient which the serum could not be expected to overcome.

In Great Britain the honour of having been the first to prepare the anti-toxin after Roux's method falls to the British Institute of Preventive Medicine, the directors of which are Drs. Amand Ruffer and M'Fadyen. When in London towards the end of last October, in search of information on this and cognate subjects, Dr. J. B. Russell and myself visited the laboratories of that institution. The day of our visit is so far memorable in that we were informed that the first anti-toxin of the first horse treated was to be drawn from the animal that morning. We were in the laboratory when the jars containing the blood arrived from the stable, and thus, in a very indirect way, we assisted at the first step in the preparation of the serum in this country. From this first supply, after being "standardised," we each received a satisfactory quantity, which has been used by me upon occasions with success.

Let us turn aside for a moment to discuss the prevalence of diphtheria in this country. That this disease is on the increase is a noteworthy result of the study of its statistics. If we take England and Wales, and London (and I take the figures of Dr.

Seaton, Medical Officer of Health for Chelsea, given at the Budapest Congress of Hygiene), for different periods, but continuous, we see this clearly :—

Table I.—England and Wales.

Mean Annual Death-Rates from Diphtheria per million living, in England and Wales, and in London, for four periods of three years each :—

	1881-3.	1884-6.	1887-9.	1890-2.
England and Wales,	144	166	173	192
London,	213	227	315	377

In London, during 1893, 13,694 cases of diphtheria were notified, of which 3,195 were fatal; mortality rate = 23·3 per cent.

Table II.—London.

Number of Cases of Diphtheria and Membranous Croup notified in London from 1890 till 1893 inclusive (Allan, *The Journal of State Medicine*, Vol. II., No. 5, p. 262):—

Year.	Diphtheria.	Membranous Croup.	Total.
1890,	5,870	550	6,420
1891,	5,907	565	6,472
1892,	7,781	554	8,335
1893,	13,026	668	13,694

The statistics for this disease in London, from 1881 to 1893 inclusive, show that the death-rate per million living has risen from 172 in 1881 to 760 in 1893, and that the mortality from diseases of the throat, other than diphtheria, has fallen from 321 per million in 1881 to 120 in 1893.

Table III.—Scotland.

Deaths from Diphtheria in 1890-1-2 :—

Year.	Total Deaths.	Croup.
1890,	1,018	744
1891,	830	620
1892,	807	540

In order to arrive at an approximate idea of the total number of diphtheria cases in Scotland in each of those years—those recovering and those dying combined,—I have taken the figures for Edinburgh and Glasgow for the same years, and on the average in both cities, where notification of cases obtains, I find that one case is fatal out of every four cases reported; hence if we multiply the above total deaths in Scotland by 4, we get approximately the total cases of diphtheria, thus :—

Year.	Total Deaths.				Approximate Total Cases.
1890,	1,018	×	4	=	4,072
1891,	830	×	4	=	3,320
1892,	807	×	4	=	3,228

In addition to these figures, we have, under the heading of "Croup," doubtless hidden cases of diphtheria, which, however, we need not discuss further.

From the Report of the Board of Supervision for 1892-3, we learn that from 3,139,549 of the total population of Scotland—that is to say, 93·2 per cent.,—in which the system of notification of infectious diseases prevails, the number of cases of diphtheria and membranous croup notified was 2,655; in the case of the former disease, however, the death-rate was 25·6 per cent., and of the latter 43·1 per cent.; and for the year 1893-4, out of a population of 3,539,823—the estimated population of Scotland for that year being 4,025,647,—the number of cases notified of diphtheria and membranous croup was 3,523, the death-rate from the former being 25·8, and from the latter 55 per cent.

Table IV.—Glasgow.

Return of Cases of Diphtheria and Membranous Croup from 1890 (the year of the introduction of the Notification Act) to 1894 inclusive:—

Year.	Cases.	Deaths.	Mortality per cent.
1890,	581	137	23·58
1891,	479	132	27·55
(Figures from "Greater Glasgow" follow.)			
1892,	581	163	28·05
1893,	827	208	25·15
1894,	967	254	26·26

Table V.—Edinburgh.

Return of Cases of Diphtheria from 1887 to 1894 inclusive:—

Note.—The Notification of Infectious Diseases came into force in Edinburgh in November, 1879.

Year.	Cases.	Deaths.	Mortality per cent.
1887,	256	57	22·26
1888,	255	65	25·49
1889,	354	98	27·68
1890,	361	85	23·54
1891,	207	48	23·18
1892,	203	42	26·9
1893,	251	62	24·7
1894,	362	86	23·75

STATISTICS OF THE TREATMENT OF DIPHTHERIA BY THE ANTI-TOXIN METHOD.

We learn from the *British Medical Journal*, Vol. II., 1894, p. 545, that the earliest published cases of this treatment were recorded in the *Deutsche Medicinische Wochenschrift*, April 27th, 1893, by Behring and Kossel. They were 30 in number, of which 24, or 80 per cent., recovered. In April, 1894, Ehrlich, Kossel, and Wassermann published in the same journal the results of 220 unselected cases treated with the serum of goats rendered immune by giving them increasing doses of dead diphtheria bacilli (cultures). Of the 153 cases of this total in which surgical procedure was not required, the mortality was 23·6 per cent. Then, in July of the same year, and in the same journal, Weibgen, from Hahn's Clinic in Berlin, reported 65 cases; certain cases of this total required the operation of tracheotomy, of which 44 per cent. recovered; of the others, 72 per cent. recovered. It must be noted, however, that the type of disease was benign.

If we turn to the French figures, the results of the treatment seem more striking. Generally speaking, the mortality from diphtheria in the Parisian hospitals, according to Roux, had scarcely ever been, prior to the serum treatment, below 50 per cent.; since its use, the mortality has fallen to less than 24 per cent., all the cases being diagnosed bacteriologically. For instance, in the diphtheria wards of the Trousseau Hospital, for the four years before the commencement of this treatment, the mortality was 51·7 per cent. of the total cases. From 1st February to 24th July, 1894, the new treatment was used in 448 children, of whom 109 died—the mortality per cent. being 24·5. During the same time, at the Trousseau Hospital, the old lines of treatment were persevered in; of 520 total cases, 316 died—the mortality rate being 60 per cent. To show that, in the period of time chosen, the results were not attributable to a benign type of disease, Roux points out that, of the cases treated by serum at the Hospital for Children, the mortality fell to 12 per cent., while, during the same period, at the Trousseau Hospital, without serum, the mortality was 32 per cent.

Perhaps one of the most convincing statistical results that has yet been printed was that which was given by the veteran pathologist, Virchow, in a discussion on the merits of this treatment at the Berlin Medical Society. The discussion was opened

by Dr. Hansemann in a speech showing uncompromising opposition to the treatment. Virchow followed later, and, as a previous speaker had remarked while speaking that "a burnt child shuns the fire, and from tuberculin I had carried away bad burns," it was to be expected that Virchow's views would be characterised by considerable caution and conviction. He told his audience that the new treatment was begun in March, 1894, in one of the Berlin hospitals, and that, by June and July, all the diphtheria cases admitted were treated with the serum.

The results were as follow :—

TABLE VI.

	Children.	
Weeks.	Cases Cured.	Deaths.
1	13	1
2	9	1
3	6	2
4	12	1
5	6	2
6	1	1
7	3	0
8	5	0

At this point the supply of serum suddenly ceased, because of the death of the horses which were supplying it; and the hospital staff were compelled to fall back on the old lines of treatment. This was the result :—

Weeks.	Cases Cured.	Deaths.
1	5	7
2	6	8
3	6	6
4	8	11
5	8	5
6	8	12
7	13	6

Alarmed at the increased mortality, the hospital authorities obtained a new supply of serum, and began to use it. The following was the effect :—

Weeks.	Cases Cured.	Deaths.
1	3	2
2	4	1
3	14	1
4	14	2
5	17	1
6	17	5

That is to say, slumping the figures together, the total number of cases was 533. Of these, 303, *treated with serum*, had a mortality of *13·2 per cent.;* while the remainder, *treated without serum*, had a mortality of *47·8 per cent.* After the narrative of these facts and figures, Virchow added that "all theoretical considerations must give way to the brute force of these figures"; and while he held it to be the duty of every physician to use this remedy in every case of diphtheria, he frankly owned that he could not explain its action. Prof. Baginsky, of the hospital in which these results were obtained, corroborated the accuracy of the foregoing statistical details, and added that "no previous remedy had done for diphtheria what the serum had done."

If we turn to our own country, we obtain evidence of the value of the treatment in the Annual Report of the British Institute of Preventive Medicine (*Lancet*, 2nd February, 1895, p. 305, *et seq.*):—

TABLE VII.

Illustrating Treatment of Diphtheria at the Western Fever Hospital, London:—

WITHOUT ANTI-TOXIN.

Cases admitted from November 26, 1893, to January 25, 1894—

Age Periods.	Admissions.	Deaths.	Percentages.
0 to 5 years,	20	12	60
5 to 10 ,,	21	6	28·57
10 to 15 ,,	7	—	—
Upwards,	10	1	10
Totals,	58	19	32·85

TABLE VIIA.—WITH ANTI-TOXIN.

Cases admitted from November 26, 1894, to January 25, 1895—

			Type of Disease.			Complications.	
Age Periods.	Admissions.	Deaths.	Severe.	Moderate.	Mild.	Rashes.	Arthritis.
0 to 5 years,	40	5	15	18	7	10	1
5 to 10 ,,	22	5	13	7	2	6	1
10 to 15 ,,	4	—	2	2	—	3	2
Upwards,	2	—	2	—	—	1	—
Totals,	68	10	32	27	9	20	4

Death-rate = 14·7 per cent.

The foregoing cases were all certified by bacteriological diagnosis.

In the North-Western Fever Hospital, of 43 cases, diagnosed as before, treated with serum, only 2 were fatal—the mortality rate being 4·6 per cent. Of these cases, only 7 were deemed severe.

Again, in a joint-paper, read before the Clinical Society of London by Drs. Washbourn and Goodall and Mr. Card, the following statistics were given:—

TABLE VIII.

Case-Mortality of Diphtheria in Children under 15 years, at the Eastern Hospital, London—

Periods.	Cases.	Deaths.	Mortality per cent.
1893,	397	166	41·8
Jan. 1, 1894, to Oct. 22, 1894,	400	144	36·0
Jan. 1, 1893, to Oct. 22, 1894,	797	310	38·8
Sept. 14, 1894, to Oct. 22, 1894 (39 days), *not treated with Serum*,	72	28	38·8
Oct. 23, 1894, to Nov. 27, 1894, *treated with Serum*,	72	14	19·4

—thus showing, in the two latter periods, from the treatment, that the mortality was reduced *50 per cent.*

The *British Medical Journal* opened its columns for the recording of cases treated in the new way, and between the beginning of November, 1894, and the beginning of February, 1895, there were 95 cases recorded by different observers: with 22 deaths—thus giving a percentage mortality of 23·1.

TABLE IX.

(Compiled from the *British Medical Journal*, February 2, 1895, p. 259.)

Total Cases.	Deaths.	Mortality per cent.
95	22	23·1

In various centres throughout the world, not only has much interest been created in the treatment, but the serum has been given a fair trial.

In the discussion at the Royal Medical Society of Vienna,

Dr. Unterholzner gave the following figures of cases treated in the Leopoldstadt Children's Hospital of that city:—

TABLE X.

Ages.	Treated *with* Serum. Treated.	Died	Treated *without* Serum. Treated	Died.
Under 1 year,	2	1	2	1
1 to 2 years,	9	5	6	6
2 to 3 ,,	7	2	7	6
3 to 4 ,,	3	0	5	4
4 to 5 ,,	2	0	2	2
5 to 6 ,,	1	0	2	1
6 to 7 ,,	2	0	2	2
7 to 8 ,,	2	0	6	1
8 to 13 ,,	3	0	4	1
Totals,	31	8	36	24

Before the Medical Society of Trieste, Dr. Germonig gave the following results of the treatment:—Of 224 cases of diphtheria treated with Behring's serum, the mortality was 20·3 per cent. The usual mortality in the Civic Hospital of that city, from 1886 to 1894, was 60 per cent. of the total cases admitted; and to demonstrate the type of disease from which the 224 cases suffered, he pointed out that of 65 cases treated without serum, 33—that is to say, 50 per cent.—were fatal.

As showing the great international interest in this new cure of an international scourge, let me draw your attention briefly to what is happening in other countries, as well as in our own, in reference to the institution of measures for the preparation of the serum. Let us take France first.

In December last the Chamber of Deputies of that country unanimously voted 100,000 francs to the Pasteur Institute towards the expenses of the production of the serum. From this institute, since September, 1894, 50,000 doses of serum have been sent out. In Paris itself an institute has been founded, in addition to the work at the Pasteur Institute, for this special line of treatment—the municipality undertaking to defray its original cost; and the municipality, with the Department of the Seine, undertaking its annual upkeep, which is estimated to amount to £800 a year. In various provincial centres, as Lille Havre, Bordeaux, Lyons, and others, similar arrangements have been matured, and it is estimated that 140 horses will suffice for the whole of France.

In Italy, Milan has founded a Sero-Therapeutic Institute; Padua and Venice have combined to give a sum of £480 to enable Professor Bonome, of the Pathological Institute of the former city, to prepare the serum for experimental purposes, whereupon, should the report prove favourable, an institute will be founded at Padua. The Municipality of Rome, too, voted £40 to purchase serum at an early point in the introduction of the treatment.

In Germany, as we have seen, not only has the serum been extensively used, but it is being prepared in considerable quantity.

In Holland, Amsterdam has made arrangements to produce its own serum. In Spain, Ferran is preparing the serum at Barcelona. In Algiers, the Consul-Général has voted £80 to begin the preparation; other grants, as required, are to follow. In Russia, the serum is being prepared at the St. Petersburg Institute of Experimental Medicine, and the demand for it is so great that in two weeks 2,500 bottles have been sent out. In Cuba, at the town of Havana, the serum is being made at the Bacteriological Laboratory in connection with the *Med. Chir. Chronicle* of Havana. In Austria, Professor Paltauf has been entrusted with its preparation for that country. In Cape Colony, the Government bacteriologist is making the serum, and the Government are maturing a scheme whereby, at different centres, the bacteriological diagnosis of the disease may be made.

In the United States of America, the House of Representatives have appointed a National Commission to investigate the treatment. In New York, the Board of Health have instructed their Medical Officers to prepare a plan whereby the values of the different anti-toxins offered for sale may be determined, with a view, at the same time, to prevent worthless material being sold; and the municipal authorities of that city have placed £6,000 at the disposal of the Board of Health towards the application of the treatment. The Massachusetts State Board of Health and the Board of Health of Boston are now preparing their own serum.

In our own country, the Local Government Board authorised Dr. Klein to make researches into the subject and to prepare the serum, which he has done, and is doing, after the method I have already described. The British Institute of Preventive Medicine, as has already been said, was the first in this country to prepare the serum. At present it has 21 horses under treatment, 20 of which are ready for use, and the serum now prepared is of such strength that "·0001cc., mixed with a quantity of toxine, fatal to

a guinea-pig in 24 hours, will prevent the recurrence of any symptoms." Dr. Ruffer has succeeded in perfectly drying the serum without any loss of its potency, so that, when about to be used, it can be re-dissolved in a small quantity of distilled sterilised water. The Goldsmiths Company of London have given £1,000 to the Joint-Laboratory of the English Colleges of Physicians and Surgeons, which is under the direction of Dr. Sims Woodhead, for the purpose of preparing the serum. The Metropolitan Asylums Board have also determined that the serum should be used in the treatment of diphtheria in the various hospitals under their management. To-day, the supply of serum in this country is ample.

The Bacteriological Diagnosis of Diphtheria.

There is always a certain series of cases happening annually within the experience of the medical profession regarding the exact diagnosis of which—as to whether they are diphtheria or not—uncertainty prevails. This is due to the indefinite character of the physical symptoms. Hence, on occasion, a family may be thrown into unnecessary alarm, or lulled into a false security. We are now, however, in the fortunate position of being able to have our suspicious and indefinite cases of this disease diagnosed definitely and absolutely by means of bacteriological investigation. This, too, can be done very speedily by the skilled bacteriologist; indeed, within 24 hours of the receipt of a bit of cotton which has been used to brush the throat, he is able to say conclusively whether or not the diphtheria bacillus is present or not. It will be obvious that this attainment is of the greatest possible importance, since it declares at once whether or not we have this enemy to do battle with. Not only will it be of great utility in private practice, but it will also prevent a case with suspicious sore-throat being placed at once in a diphtheria ward of an hospital, while all the time it is a scarlatinal sore-throat. The danger to both new-comer and the occupants is reciprocal, and may result in serious complications or protracted illnesses.

By this form of investigation, too, the physician is enabled to say definitely that a case which is convalescent is, or is not, free of infection by the absence of the bacilli from their usual position. The period of infectivity of this disease, as in other infectious diseases, is by no means constant. While it may be said that, in the large bulk of cases, this period does not extend beyond 21 days,

examination by this method has revealed the fact that the bacilli of the disease are still to be found in the air-passages of the person, who, from all the other symptoms, looked quite free of the disease. Bacilli have been found in the air-passages of convalescents at the end of *four* and even of *five* weeks from the commencement of the attack, thus showing that they are still *infectious* persons.

Again, this mode of investigation would also prove of great value where, for instance, diphtheria attacks one child of a household, and where, for various reasons, it is proposed to take the other children, who are apparently quite well, to other places, but one or more of whom may take the disease later in their temporary homes. Experience abundantly has established this latter fact. Now, bacteriological examination would clear up which of them were infected and which were not.

The Nature of the Bacteriological Examination.

Where there are patches of any kind on the throat, or even where there are none, all that is required by the physician is to brush the throat of the patient with a pledget of sterilised cotton-wadding, place the wadding in a sterilised test-tube, forward it to an expert bacteriologist, who, within 24 hours, will, in practically every case, be able to say whether or not the diphtheria bacillus is present in the throat, because, when placed under suitable conditions, it grows so rapidly in appropriate culture media.

The value of an institution wherein such examinations can be made at a moderate charge is alike great to the public and to the medical profession, and provisions for such have already been made in the laboratories of the British Institute of Preventive Medicine and that of the Colleges of Physicians and Surgeons of London. Such an institution would be of the greatest importance and value in Scotland, whether undertaken by private subscription or by municipalities.

Hitherto Glasgow has been in the forefront of every sanitary movement in this country, and, probably, there is no tax which is paid more cheerfully than that for the purpose of maintaining and conserving the health of its inhabitants collectively; but in this department nothing has yet been done. However, many of us, who are interested in public health schemes, are hopeful that, in the new Sanitary Chambers, there will be found, as one of its

most important departments, a laboratory presided over and directed by a skilled bacteriologist, wherein such important investigations as have been indicated would be carried out. Such a laboratory would be invaluable, and would lead to much valuable life being saved.

If a precedent be desired for such a laboratory as this, instituted and maintained under a municipality, let me direct your attention to what the municipal authorities of New York have done and are now doing. So far back as 1887, the Port Health Authorities of New York instituted bacteriological examinations for the diagnosis of cholera, which were reported to be of "incalculable" service. In 1892 the City of New York followed their example by establishing a bacteriological laboratory. Out of this movement the investigation of doubtful cases of diphtheria followed as a matter of expectation, and, in 1892, examinations of about 4,000 cases of the disease in the health hospitals were made.

Dr. Herman Biggs, at the Congress of the British Institute of Public Health held last year, gave a full account of the work done in this particular direction in that laboratory, and his paper was published in the *Journal of State Medicine* for November, 1894 (Vol. II., November, p. 267). He pointed out in his paper that the value of such work was priceless, and every opportunity was afforded the medical profession of that city to have preliminary bacteriological examinations made by the officials of the laboratory of all doubtful or suspected cases of diphtheria. That this was recognised as a great boon by the medical profession, and as showing also the need that exists for such an institution, he pointed out that, in the first year of the operation of the scheme, 5,611 cases had been made the subject of examination, of which about two-thirds were proved to be true diphtheria. The New York Board of Health was, therefore, the first in the world to take this important step in advance. This example has since been followed by other large cities, by the Marine Hospital Service, and by the Medical Corps of the Army of the United States, and it is worthy of being copied by large centres of population like our own.

Preventive Use of Serum.

The serum, hitherto, has been mainly used as a curative agent; but it may also be used as a *preventive* agent--that is to say, in the event of one young member of a family being seized with

undoubted diphtheria, it would not only be necessary to inject the serum into its body, but it would be highly expedient to inject smaller doses into the other children, who, perhaps not yet affected, may either have been exposed to the same source of infection, or may be in process of incubation from their sister or brother.

To a limited extent, this would be like vaccinating against smallpox where one person was seized with the disease, while those who were in contact with him did not as yet show signs of the disease.

There is this, at least, to be said in favour of its use as a preventive, that the operation is trifling, is harmless, and, if aseptic precautions have been taken, without risk.

Objections.

All the objections that have been urged against the new treatment may be divided into two main classes, namely:—

I. Those that have been made by persons who object to animals being used for any scientific purpose; and

II. Those, by certain of the medical profession, to the effect that the use of the serum is not unattended with uncomfortable consequences, if not, indeed, grave complications; and, further, that while it is admitted that the anti-toxin is antagonistic to the Lœffler bacillus, the disease which the bacillus produces is, they say, not diphtheria.

To the first class of objectors, it may be conceded that the aimless cruelty to animals, whether under the name of a scientific experiment or under any other name, is a thing which is, and ought to be deprecated, by all right-thinking persons; but, on the other hand, where, in the saving of human life, the sacrifice of animal life is necessary, much stronger reasons must be produced to convince a right-minded person that such sacrifice is a sacrilege or a sin; for, whether from a religious or an economic standpoint, human life is always the most important.

One cannot help thinking that the deputation which was recently headed by Lord Coleridge, and which protested against the use of animals for the production of the serum by the British Institute of Preventive Medicine, failed to serve a useful purpose when it attempted to interpose between the reasonable use of animals and the cure of one of the most fatal and most dreaded

scourges of the nineteenth century; not only so, but to be logical, it would require to protest against the use of the bodies of animals for the production of a protective vaccine against the diseases of the same class of animals, as is exemplified in anthrax.

As it is written in the Holy Scriptures, "Fear not, therefore, ye are of more value than many sparrows" (Luke xii. 7).

Of the second class of objections it may be said that, while it is true that the use of the remedy does cause, upon occasion, certain disagreeable consequences, such as nettle-rash, pains in joints, &c., it must, at the same time, be said that there has not yet been recorded a single case to which the death could be attributed to the serum when properly used; and we can safely neglect, in view of the very beneficial results which follow the remedy, those minor and transitory ills.

Experience of the serum has now abundantly proved that it exercises a directly curative effect on the disease, that from it we may reasonably expect lessened mortality, and the sparing of many useful young lives; and now, as Virchow put it, no physician would be justified in withholding its use from a patient suffering with the disease.

XII.—*Four Great Periods of Italian Art.* By T. L. WATSON, F.R.I.B.A.

[Abstract of President's Opening Address, delivered to Architectural Section, 17th November, 1894.]

FOUR periods stand forward prominently in the history of Italy and of Italian Art :—(1) The period of antiquity, during which Rome dominated, not only Italy, but Southern and Western Europe, and portions of Asia and Africa; (2) the Byzantine period, dating from 329 A.D., when the seat of empire was transferred from Rome to Constantinople—the Ancient Byzantium; (3) the Mediæval period, which, beginning about the tenth century, gave place in the fifteenth century to the last short and brilliant period (4) the Renaissance, which, so far as greatness in the arts is concerned, terminated soon after the middle of the sixteenth century.

My intention is to occupy a short time mainly with the art of the Middle Ages and the Renaissance; but I have thought it necessary to refer, however summarily, to the architecture of ancient Rome, and to the period of Byzantine art, because it is the peculiarity of the Mediæval period in Italy that it is always under the influence of the art of antiquity, not only in its beginning, but right on through its whole course, while in particular districts the Byzantine influence is also apparent. In France, Germany, and England, Roman influence was strong up to the twelfth century, and the architecture of this period is appropriately termed Romanesque. But with the birth of true Gothic architecture in the twelfth century, the direct Roman influence in these countries may be said to have disappeared. In the south of France it lingered a little, but, speaking broadly, we have in the northern countries, from the end of the twelfth century, a new architecture, which shows hardly a trace of the Roman works from which it took its origin. In Italy it is altogether different. The pointed style of architecture did not originate in that country; it was an

importation, and it was imported into a land in which the round-arched architecture of Rome had been firmly established for more than a thousand years. While in Northern Europe pointed architecture carried everything before it, in Italy the Roman influence was too strong. There the two styles grew together, and a degree of fusion took place between them, producing the style, or rather the styles, which we call Italian Gothic. It is this fact which makes the architecture of mediæval Italy so interesting at the present time, when our position with reference to Classic and Gothic architecture offers certain points of analogy with that of Italy during the Middle Ages.

When we speak of Italian Gothic, it is necessary to discriminate. It is characteristic of Mediæval architecture that it is especially subject to local variation. Every county of England and every department of France may be said to have its own peculiarities of style, the members and features of its architecture varying everywhere by reason of its environment. Social and political differences, as well as differences of material, and other conditions, produce endless variation. But this variation is nevertheless within recognised and moderate limits, and we have no hesitation in ascribing all the architecture of a given period in those countries to one style. In Italy, however, the variations are so great that we are justified in saying that at least four or five different styles of architecture flourished contemporaneously during the Middle Ages. We have an architecture in which French influence is strong, which is, indeed, almost as much French as Italian. In Venice we have one largely derived from Byzantine architecture. There is the Romanesque Gothic of Florence, and again the purely Italian Gothic of Orvieto and Siena. Each of these is so dissimilar from the others that it is misleading and confusing to speak of them merely as Italian Gothic. They reflect the political condition of Italy at the time, and are independent styles to an extent found in no other country.

In spite of this diversity of styles, there are certain leading characteristics which run through them all in a greater or less degree. First, there is the one to which I have already referred, the influence of the classical art of antiquity, which is felt throughout the whole Gothic period in Italy. This is seen in the general effect of breadth, in the horizontal treatment and flat surfaces, as opposed to the vertical treatment and deeply-recessed openings and mouldings of Northern Gothic. It is seen in the

mingling of round and pointed arches, in the fondness for the single round pillar or shaft in place of clustered or grouped columns, and for the tapered form of pillar instead of the cylindrical or parallel-sided form which is almost invariable in the north. It is seen particularly in the sculpture. In foliated sculpture we have the acanthus and the scroll scarcely modified from the best Roman work. In figure sculpture there is very little trace of what we call Gothic feeling or expression. It is Roman sculpture refined and spiritualised. We have heard much and often of the incongruity between the finest sculpture and Gothic architecture, but those who use this language know little of the best French and English, and still less of the best Italian sculpture of the Middle Ages.

The second characteristic of Italian Gothic that I would notice is a defect of what may be called the constructive sense in design. One indication of this is the general absence of abutment to the arches, involving the use of the iron tie-rod to hold them together. It may be argued that this is good construction and equally good design, as the tie-rod is as much in evidence as the arch itself. It is certainly better to have the tie-rod openly employed, if it is required, than to have its use in some way concealed or evaded, so that an arch or series of arches is maintained apparently by a suspension of the law of gravitation. The tie-rod may sometimes be permissible, it may even be admirable, but, speaking generally, it is less satisfactory than the Roman and northern method of meeting the thrust of an arch by a sufficient abutment or by an opposing thrust. But the iron tie-rod is not the only evidence of this defect of the constructive sense in mediæval Italy. We constantly find heavy walls or piers carried by slender shafts apparently quite unequal to their task. The fact that they are still standing after six or seven hundred years is proof that they are really strong enough from the merely structural point of view. From the point of view of design something must be allowed also for the known hardness and strength of marble as compared with the building stones to which we are accustomed. After every allowance has been made, however, it must be admitted that the apparent weakness and instability of many Italian buildings is a characteristic and serious defect, due, perhaps, in some measure, to the fact that the construction is so frequently concealed by the decorative material in which they are encrusted.

Another characteristic of Italian Gothic to be noticed is one which is to some extent dependent upon the same circumstance, but one that, so far from being a defect, is one of the great beauties of Italian architecture. I refer to the almost universal use of beautiful colour. The colour that was largely used in northern work of the same period has nearly all disappeared, and we find it difficult to realise even that it existed; but in Italy we still find wealth of colour. We find it in the marbles with which most of the buildings were encrusted, in the brick and terra-cotta largely used in some districts, in mosaic decoration, and in fresco and other painting. The colour, whether of material or pigment, is not merely applied to the buildings: it belongs to them; it is always part of the architecture, and sometimes a chief part of it. It is to Italy that we must go to find painting really allied to architecture, not merely applied to it. Many of the Italian painters were also architects, and even those who were not showed a keen appreciation and full knowledge of architectural form and proportion. The architecture which they painted as accessory to their figures was in harmony with that of the buildings decorated, and established a bond of relationship between them. Not only so, but the figures themselves were imbued with the architectural qualities of symmetry, restraint, and repose, and were not degraded, but, on the contrary, much dignified by this treatment. The painter, when he was not also the designer of the building, was his successor. An architect himself, he carried on the work of architecture to its completion. This is especially characteristic of the Gothic period and of the early Renaissance, and it can be fully appreciated only in Italy.

With the Renaissance, in the fifteenth century, there came the revival of Classical learning, and, in Northern Europe, the re-introduction of the Classical architecture of ancient Rome. Italy witnessed more a change of spirit than of form in her architecture. Outwardly, at least, the change was less abrupt than it was elsewhere. While Gothic forms were discarded, it can hardly be said that Classic forms were introduced, as these had persisted through the Gothic period, at least, over a considerable part of Italy. For a short time the period of the Renaissance was one of the most brilliant, if not also one of the greatest, in the history of art. It produced two of the greatest geniuses of all time, with a host of inferior, but still great artists. If the change in outward style between the middle ages and the Renaissance was less in

Italy than elsewhere, the change in spirit was at least as great and as rapid. From Giotto and Fra Angelico to Raphael and Michael Angelo there is a complete revolution, and yet the death of Angelico was separated from the birth of Angelo by only twenty years. The earlier years of the Renaissance produced in profusion the most graceful and beautiful works of architecture, painting, and sculpture, but they were followed by swift deterioration. Before the close of the sixteenth century, architecture had lost its vigour, purity of form, and delicacy of detail. In the seventeenth century it became profuse, ornate, and, in spite of some remaining elements of grandeur, generally bad. In painting and sculpture there were still great names, but these arts were more and more separating themselves from architecture, and, in doing so, losing their finest qualities, not only in their association with architecture, but even as independent arts.

Mr. Watson's address was illustrated by about a hundred lime-light views of some of the buildings of the several periods, with details of their architectural features and of their sculpture and decorative painting. The period of ancient Rome was illustrated by views of the Temple of Castor and Pollux and of the interior of the Pantheon. The Byzantine period was shown by a series of views of the churches of Ravenna, with several of their exquisitely sculptured capitals; and the beautiful mosaics of Ravenna were also shown and described. In the architecture of the Middle Ages the persistence of Classical types was shown to be very strong in the towns and districts of Pisa and Florence, as well as further south, while the Byzantine influence was illustrated most fully in Venice. The cathedral and the church of St. Anastasia at Verona were shown, the beautiful west door of the latter by a series of details. The west front of the cathedral of Ferrara, with its skilful and harmonious union of thirteenth with twelfth century work, was fully illustrated, and its constructive defects were pointed out, and contrasted with the English and French work of the same period. Next came the cathedrals of Orvieto and Siena, and a series of views of the most important buildings of Rome, Florence, Genoa, and other cities, completed the illustrations of the periods of the Middle Ages and the Renaissance. In sculpture the schools of the Pisanos and the Della Robbias were shown by

numerous works, and illustrations were given of the works of Ghiberti, Donatello, Della Quercia, Benedetto da Majano, Michael Angelo, and others. Among paintings were shown some of the great works of Giotto, Fra Angelico, Benozzo Gozzoli, Fillipo Lippi, Ghirlandajo, Raphael, Andrea del Sarto, and Domenichino. The concluding views were of St. Peter's at Rome. Michael Angelo's magnificent dome was described, and it was shown how much his work and Raphael's had been obscured and defaced by that of subsequent architects.

XIII.—*Sugar Manufacture in Australia.* By THOMAS STEEL, F.C.S., Sydney, late of Greenock. Communicated, with Introduction, by T. L. PATTERSON, F.I.C., F.C.S., Greenock.

[Summary of Paper read before the Society, 1st May, 1905.]

MR. PATTERSON said that, at a recent jubilee celebration of the Colonial Sugar Refining Company, the senior partner was presented with, amongst other things, an illuminated album, containing platinotype photos. of the different establishments of the Company. In making up the album a number of negatives were specially prepared, and they, with others previously taken, were given to Mr. Steel for the purpose of preparing lantern slides. The photos. that were to be thrown on the screen were copies of them, and duplicates of a set used by Mr. Knox, the managing partner of the Company, to illustrate a lecture delivered by him in Sydney. They had been sent home by Mr. Steel, with Mr. Knox's kind permission, so that they might be used in illustration of the paper by Mr. Steel on "Sugar Manufacture in Australia," which he (Mr. Patterson) was about to read, and which was meant to be descriptive of the slides, rather than an essay on sugar.

Before doing so, however, it was necessary that he should tell them, in as few words as possible, something of the Colonial Sugar Refining Company, as Mr. Steel, in his remarks, confined himself to the plant and operations of the Company.

If the American Sugar Trust were excluded, the Colonial Company was, perhaps, the largest sugar concern in the world. It not only refines, and turns out of its refineries, upwards of 2,000 tons of sugar weekly, but it grows and extracts from the cane, in its numerous mills, a large proportion of the raw sugar consumed in the refineries, besides purchasing extensively in Java, Mauritius, and elsewhere.

Situated, as the refineries are, where supplies are not so easily obtained, the Company have to carry on several subsidiary manufactures to meet their own requirements and get rid of

waste products. Hence they make their own charcoal, and work up the by-products, using the gas for lighting the refineries, and the ammonia in manure-making. The spent charcoal is utilised in the manufacture of superphosphate, so that they carry on an extensive fertiliser trade. In connection therewith they use large quantities of vitriol, and, because of the difficulty of transport and trouble with inter-colonial fiscal arrangements, it is in contemplation to erect vitriol works of their own in one or two of the colonies. They have even adopted the trade of tinker, to meet their own wants, by establishing a factory in which they make tins for use in syrup-packing. They have, besides, the usual workshops, fitted with machine tools, for the accommodation of the large staff of tradesmen employed on the premises.

At the mills, which are still more isolated than the refineries, the Company have also to provide house accommodation for officers and labourers; and hospitals, with doctors and nurses, in which to treat those persons who are laid aside by illness. They have to make their own railways, and build and maintain a flotilla of barges for cane transport. In these and in many other directions their operations have extensive ramifications which would not be considered necessary if the work were carried on in a manufacturing and populous country like ours.

Of course, so large a concern could not be conducted without efficient control; consequently, a staff of chemists and engineers is to be found at every establishment of the Company; and it is worthy of remark that the heads of refineries, mills, and business departments are, in many instances, Greenock men, trained in the refineries there. Mr. Walton, chief chemist and scientific adviser to the Company, is a Greenock man, so also is Mr. Steel, and there are several others who could be named. But the success of the Company is not wholly the result of Greenock experience, although that has been a valuable element in it. It is largely due to the isolated position which is held by the Company, or rather to the fact that the concern has so long enjoyed a complete monopoly of the refining industry in Australia. Its position is now so secure that no opponent is able to compete with it. Only last year it bought out a refinery, erected in Melbourne, which had been running two or three years, and it has done the same thing on former occasions. Under these circumstances, it is not a matter for surprise that this concern commands prices for its products which would cheer the heart of a Greenock refiner, and

make a Glasgow sugar-broker stare. Moreover, the trade is protected by a small duty, which keeps out foreign competition, and makes the position of this enterprising Company almost unassailable.

Mr. Patterson now proceeded to read Mr. Steel's paper, which was very fully illustrated by the photo. views referred to in his opening remarks.

The manufacture of sugar, said Mr. Steel, is an industry which has attained very considerable dimensions and a very fair degree of perfection in Australia. Although, up to the present, we have not produced sufficient for our own consumpt, but have had to draw largely on Java and Mauritius, the time is now rapidly approaching when more than the whole quantity required will be produced within our own shores, and our four millions of people will practically derive all their supplies of sugar—amounting to about 168,000 tons per annum—from their own home production.

I have less hesitation in laying before you an outline of the condition of this great industry in Australia, and of the general methods in use for the extraction of the sugar from the canes, when I reflect that almost the whole of the machinery used in the manufacture and refining of sugar in these colonies has come from the workshops of Greenock and Glasgow, and how intimately the industry concerns the Clyde district.

Although I am speaking nominally of Australia, my remarks will cover, not only it, but also New Zealand, Tasmania, and Fiji, which are usually embraced in the term Australasia. The whole of the sugar manufactured in Australia is the product of the sugar cane, whose cultivation is confined to Queensland, the north of New South Wales, and to Fiji, but it will doubtless in time extend to the tropical portions of the other colonies, such as the northern territory of South Australia. The cultivation of beet-root has at different times been initiated in some of the southern colonies, but it has never been a commercial success.

All the views to be shown are illustrative of the operations of the Colonial Sugar Refining Company, Limited, the largest industrial corporation in Australia, and one of the most progressive—having no less than ten sugar mills at work in Australia and Fiji, five refineries in as many different colonies. nd an eleventh mill now being built on the Isis scrub, Queensland. Of these mills, three are situated in Queensland, three are

in New South Wales, and four are in Fiji; while there is a refinery in each of the following colonies:—New South Wales, Victoria, South Australia, New Zealand, and Queensland. The first operation in connection with the production of sugar is, of course, the preparation of the land. The dense growth which in Australia covers the virgin soil has to be removed, and the land broken up and cultivated for the reception of the cane plants.

The first slide shown represented a general view of the Isis scrub; in the near foreground the dense growth of trees and bushes, termed scrub, had been cleared, while the untouched forest was seen beyond. Next there was shown the operation of clearing—the trees being cut down, allowed to dry, and then burnt off. By placing heaps of brushwood over the stumps previous to firing, these were burnt out. The next two slides showed further stages in the clearing; and then came a field of young growing cane, in which some tree stumps were still standing, and a number of South Sea Islanders, or, as they were called "Kanakas," employed in the cultivation, were seen in the field. In the next picture there was the camp scene, a typical example of camp life in the bush. The camp was pitched on the spot where the new Isis Mill is now being erected, and was occupied by the men engaged on the necessary preliminary operations.

Then was shown a view of Condong Mill, on the Tweed River, New South Wales. River-bank situations are chosen for the mills for convenience of transport of the cane, which can very cheaply be conveyed for great distances in the large open punts. where otherwise the cost of land haulage would be prohibitive, (The appliances embraced in this view were very numerous, and showed that the mill was thoroughly equipped.)

The punts used for the conveyance of the cane are open barges, built of iron, and capable of carrying 30 to 35 tons of cane. In the next two slides the building of these punts was shown. For the conveyance of the punts to and fro, steam tugs and launches are used, and the following slide gave a view of the little steamer *Eurella*, one of the launches at Condong Mill. That mill is fitted with a double-crushing plant, the cane between the two crushings being saturated with boiling water, a practice which is termed double-crushing, with maceration.

In another picture a view was given of the Company's Harwood Mill, on the Clarence River, New South Wales. The sacks of

raw sugar were seen being carried from the store in the mill and dropped into the hold of the steamer, for conveyance to the refineries. When the mill is at work, the interesting sight may be witnessed of the double stream of cane going in from the punts and the line of sacks of sugar going out to the deep-sea steamer. Harwood Mill has two double-crushing plants, and is thus just double the capacity of Condong.

The remaining New South Wales mill—the largest in the Company's possession, and said to have the largest working capacity of any yet built—is Broadwater Mill, on the Richmond River. Within the last few years this mill, a view of which was now shown, has been entirely rebuilt and remodelled, and is now as modern and well equipped as any sugar mill in existence. It has three double-crushing plants, of the same type as those at Harwood and Condong.

One of the latest appliances in connection with the crushing operation is the "cane shredder," a machine which is fitted in front of the cane mill. Its purpose is to submit the cane to a preliminary shredding or tearing operation, a treatment which greatly aids the subsequent crushing, enabling better extraction to be done with less addition of maceration water. A shredder in the workshop, ready for sending to be erected at the mill, was shown in one of the views.

In several of the following pictures views were given of the crushing mills and their engines, the "megass" mill, the clarifiers (in which the juice is dealt with), the vacuum *triple effèt* apparatus, and the centrifugal machines (in which the grained sugar is separated from the molasses).

Next in order came a view of Homebush Mill, which is situated at Mackay, in North Queensland. It afforded some notion of the difficulties involved in the erection of a large mill in the wilds of Queensland. The picture illustrated the conveyance of the bottom part of a multiple-evaporating plant by bullock teams from the seaboard to the mill. This piece of machinery required for its conveyance a team of 42 bullocks, and it was carried on a specially-built wagon.

At a later stage were shown two views of Victoria Plantation, in North Queensland, under different conditions. In the first there were seen the fields of cane, with a bridge over a creek; then there was the same scene in flood-time, in which bridge and fields were submerged, and a gang of "Kanakas" were busily

engaged endeavouring to push off a floating island to prevent damage to the bridge. These curious floating islands are composed of dense masses of vegetation, often with fair-sized trees growing on them, and are washed down by floods, and frequently carried right out to sea.

Several slides followed which showed other difficulties that are encountered in flood-time, and the use of locomotives for land traction where the mills are not situated on navigable rivers.

At Goondi Mill, Johnstone River, Queensland, of which a picture was shown, Javanese are largely employed, and a picture of a typical group of these people was projected on the screen. At all the Company's establishments the whole operations are conducted under close chemical supervision, there being an efficient chemical staff and laboratory. The chemical laboratory at Goondi Mill was shown in illustration.

It is rather difficult to get a clear photograph of growing cane, because of the density of the close-growing stalks, but a view was given of a few isolated plants growing in the experimental nursery which is conducted at Goondi Mill. It gave a fair idea of the appearance and character of growing cane. A view of the hospital attached to Homebush Mill having been shown, leave was taken of Queensland, and then a considerable number of slides were "screened" to illustrate the Company's mills and plantations in Fiji, where the labour employed is mainly that of Indian coolies.

Most of the remaining pictures were illustrations of the Company's refineries. They were chiefly intended to show some special features or processes at the Pyrmont Refinery, Sydney (which is the Company's principal establishment of the kind); the Chelsea Refinery at Auckland, New Zealand; Yarraville Refinery, Melbourne; Glanville Refinery, Adelaide; and the New Farm Refinery at Brisbane, the most recent of them all, having started work a little over a year ago.

XIV.—*The New Rules by the Board of Trade as to Colour Testing for Mariners and Railway Servants.* By Freeland Fergus, M.D.

[Read before the Society, 3rd April, 1895.]

With Coloured Plate.

Two years ago I had the honour to read, before the Philosophical Society, a short paper on the "Light Sense in its relation to Navigation." In that paper I took occasion to suggest that the danger of that form of defective vision, generally known as congenital colour-blindness, sometimes called "Daltonism," was not, to any great extent, a serious danger to navigation, and that of late years the supposed danger had been unduly magnified. To-night I wish to devote almost the entire time at my disposal to this aspect of the case, for I cannot but feel that grave injustice has been done to many seafaring men by the regulations lately issued by the Board of Trade. There is presumably no person who does not desire everything in reason and equity for the public safety, and when it is proved that a man has a defect which renders it dangerous that he should occupy a certain position, then, of course, public safety may demand that he should not be allowed to hold it. It is because I believe that the vast majority of colour-blind persons can distinguish perfectly between a port and a starboard light that I have ventured to trespass on the time of the Society. Fortunately my argument is an appeal to facts. I do not think that it is material to the point that I have no theory of colour-blindness, and do not see my way to accept either the Young-Helmholtz theory or that of Hering. These are questions which do not necessarily form part of our investigations, and that is just wherein the Report of the Committee of the Royal Society on Colour Vision, and the more recently published book by Captain Abney, have made a radical mistake. They have assumed that the Young-Helmholtz theory is accurate; at any rate, they are written on the assumption that the Young-Helmholtz theory is the one most probably true.

We cannot too much admire the efforts of the physicists and physiologists who have striven to maintain the truth of the Young-Helmholtz theory. It was the theory on which I myself was brought up by that very learned man, the late Professor Donders,

of Utrecht, and I was for a whole summer engaged with him in examining persons for colour-blindness. The instrument which he then employed was a spectroscope, giving two spectra, placed one above the other. Any portion of the one spectrum could be shut off from the rest and compared with any selected portion of the other; moreover, any portion of the upper spectrum could be placed over any selected part of the lower. In addition, the same source of light was used for the two spectra, but the amount forming each could be regulated at will. Thus, it will be seen that, to a limited extent, Donders' instrument fulfilled some of the purposes for which the splendid apparatus designed by Abney, and described at length by him in his small book on colour measurements, was contrived.

Briefly stated, the Young-Helmholtz theory is as follows:—There are three primary colour sensations—namely, a red, a green, and a dark blue. Thus, by mixing red with green in different proportions, we get the various shades of orange and yellow. Green, mixed with the blue sensation, will give us the various greenish blues; and the blue sensation, mixed with the red, will give us the purples. So far so good: all observers, moreover, are of opinion that no admixture of colours will give us red or green or this primary blue. This was an observation confirmed by Donders, and is also repeated by Abney in his recent and most excellent book on colour vision. Let this be granted, although I am not sure that so much can be granted, for I am not personally aware that any experiments have been conducted on the mixtures of the colours forming the visible parts of the spectrum with those parts which are invisible—namely, with the rays known as the caloric and actinic. The mixture of these rays with the rays of the spectrum which are visible must, of necessity, produce some change in the latter, and it has not yet been proved, so far as I am personally aware, that, for example, green cannot be formed by the admixture of one of the visible colours with one of the invisible. Let it, however, be granted that there are three primary colour sensations, or, at any rate, that there are three colour sensations which cannot be produced by the admixture of any two of the visible rays. The Young-Helmholtz theory, as is well known, predicates that in each of the retinal elements there is what may be called an end organ capable of responding to one, and only to one of these sensations. Thus, when we see a yellow, it is because the end organ for red and the end organ for green are stimulated

together. If the red is stimulated more than the green, then the resultant is an orange sensation. I need not take up the time of the meeting with further details; particulars of the theory can be obtained in any good text-book of physiology, and a masterly exposition of it can be had in the writings of the late Professor Donders. The objections to this theory are in some respects too technical to be dealt with satisfactorily on this occasion. Still one or two of them may be readily understood.

It is a mistake to talk in a physical sense of primary colours. We only know that a colour is the mental interpretation of a wave frequency. Moreover, in the frequencies of light there are not, as in sound, any which are multiples of others; there is nothing corresponding to the octave in music. Again, we have no consciousness that any colour is of more importance than another when we look at the spectrum. We can distinguish a series of colours, but no one can be said to be a primary sensation and another not. One very important objection is the fact that at the periphery of the retina only two colours are recognised. If, then, it takes at the centre of the field of vision corresponding with the centre of the retina three sensations to make white, it stands to reason that in that part of the retina where only two colours are recognised we have only two colour sensations. In this part, therefore, white, as seen with the centre of the retina by the supposed three sensations, should not appear the same at the periphery of the retina, but should appear coloured, unless these two colour sensitivities are complementary to each other. Now, so far as we observe the tone of a piece of white paper, it does not alter as it is brought over the field of vision. To us, also, the fact that any two complementary colours always make up white is most suggestive.*

Although to our own mind these objections almost preclude the truth of the theory of Young and Helmholtz, we are too well aware that they will not satisfy the partisans of this theory. We must turn to others. And, first, there have not been shown to exist in every cone of the retina three terminals corresponding to the three colour sensations. True it is that Cajal has lately pointed out that each cone is connected with several nerve fibres, but, so far as I know, there have not been proved to exist three

* For a more detailed account of the objections to the Young-Helmholtz theory, reference may be made to the Address of Professor Rutherford at the Meeting of the British Association, held in Edinburgh in 1892.

terminals in each retinal cone. So far as that goes, every cone seems to be capable of receiving and transmitting all the colour sensations indifferently. It is highly probable that the same cone responds differently to the several energies of the various coloured lights. There is nothing to prevent it. No one supposes that a different ether is required to transmit the different colours in space, and I, for one, do not see the necessity of supposing that there is any need of three terminals to transmit the sensation of waves of light to the brain. Yet if the Young-Helmholtz theory be true, every cone must have three terminals, or else for every sensation of white light three cones must be employed. We know for a fact that one cone is sufficient to record the sensation of white, and there is no anatomical or physiological proof whatsoever that it is not capable of recording every other.

But, further, the usually-accepted view of the Young-Helmholtz theory is entirely disproved by the experiments of what may be called complementary simultaneous contrast. If, with a lantern, we project a pencil of red light on a screen, then, on placing an opaque body in the red light, the shadow which it casts on the screen is, as is well known, the complementary green. Now the congenitally colour-blind see no difference between the colour of the light and the colour of the shadow. That is a circumstance somewhat difficult of explanation on the Young-Helmholtz theory.*

Interesting as such considerations are, they do not by themselves prove what I wish to establish—namely, that colour-blind persons may safely be entrusted with the duties of navigation, provided they can distinguish between a port and starboard light, and that, therefore, the new rules are, to a considerable extent, oppressive and unnecessary. I propose to show that there is no reason to suppose (1) that the majority of colour-blind persons cannot distinguish between a port and starboard light; (2) that a large number of colour-blind persons have in the past navigated, and apparently with perfect safety; (3) that there is little evidence that any damage has in the past arisen from this defect. Thereafter I shall make a few remarks as to the question in general, and, if time permit, I shall refer to defective light sense, which I still think is a much greater danger than a defective colour sense.

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* We would at least expect that the other colour sensation would affect the result.

XIII.—*Sugar Manufacture in Australia.* By THOMAS STEEL, F.C.S., Sydney (late of Greenock). Communicated, with Introduction, by T. L. PATTERSON, F.I.C., F.C.S., Greenock.

[Summary of Paper read before the Society, 1st May, 1895.]

MR. PATTERSON said that, at a recent jubilee celebration of the Colonial Sugar Refining Company, the senior partner was presented with, amongst other things, an illuminated album, containing platinotype photos. of the different establishments of the Company. In making up the album a number of negatives were specially prepared, and they, with others previously taken, were given to Mr. Steel for the purpose of preparing lantern slides. The photos. that were to be thrown on the screen were copies of them, and duplicates of a set used by Mr. Knox, the managing partner of the Company, to illustrate a lecture delivered by him in Sydney. They had been sent home by Mr. Steel, with Mr. Knox's kind permission, so that they might be used in illustration of the paper by Mr. Steel on "Sugar Manufacture in Australia," which he (Mr. Patterson) was about to read, and which was meant to be descriptive of the slides, rather than an essay on sugar.

Before doing so, however, it was necessary that he should tell them, in as few words as possible, something of the Colonial Sugar Refining Company, as Mr. Steel, in his remarks, confined himself to the plant and operations of the Company.

If the American Sugar Trust were excluded, the Colonial Company was, perhaps, the largest sugar concern in the world. It not only refines, and turns out of its refineries, upwards of 2,000 tons of sugar weekly, but it grows and extracts from the cane, in its numerous mills, a large proportion of the raw sugar consumed in the refineries, besides purchasing extensively in Java, Mauritius, and elsewhere.

Situated, as the refineries are, where supplies are not so easily obtained, the Company have to carry on several subsidiary manufactures to meet their own requirements and get rid of

waste products. Hence they make their own charcoal, and work up the by-products, using the gas for lighting the refineries, and the ammonia in manure-making. The spent charcoal is utilised in the manufacture of superphosphate, so that they carry on an extensive fertiliser trade. In connection therewith they use large quantities of vitriol, and, because of the difficulty of transport and trouble with inter-colonial fiscal arrangements, it is in contemplation to erect vitriol works of their own in one or two of the colonies. They have even adopted the trade of tinker, to meet their own wants, by establishing a factory in which they make tins for use in syrup-packing. They have, besides, the usual workshops, fitted with machine tools, for the accommodation of the large staff of tradesmen employed on the premises.

At the mills, which are still more isolated than the refineries, the Company have also to provide house accommodation for officers and labourers; and hospitals, with doctors and nurses, in which to treat those persons who are laid aside by illness. They have to make their own railways, and build and maintain a flotilla of barges for cane transport. In these and in many other directions their operations have extensive ramifications which would not be considered necessary if the work were carried on in a manufacturing and populous country like ours.

Of course, so large a concern could not be conducted without efficient control; consequently, a staff of chemists and engineers is to be found at every establishment of the Company; and it is worthy of remark that the heads of refineries, mills, and business departments are, in many instances, Greenock men, trained in the refineries there. Mr. Walton, chief chemist and scientific adviser to the Company, is a Greenock man, so also is Mr. Steel, and there are several others who could be named. But the success of the Company is not wholly the result of Greenock experience, although that has been a valuable element in it. It is largely due to the isolated position which is held by the Company, or rather to the fact that the concern has so long enjoyed a complete monopoly of the refining industry in Australia. Its position is now so secure that no opponent is able to compete with it. Only last year it bought out a refinery, erected in Melbourne, which had been running two or three years, and it has done the same thing on former occasions. Under these circumstances, it is not a matter for surprise that this concern commands prices for its products which would cheer the heart of a Greenock refiner, and

make a Glasgow sugar-broker stare. Moreover, the trade is protected by a small duty, which keeps out foreign competition, and makes the position of this enterprising Company almost unassailable.

Mr. Patterson now proceeded to read Mr. Steel's paper, which was very fully illustrated by the photo. views referred to in his opening remarks.

The manufacture of sugar, said Mr. Steel, is an industry which has attained very considerable dimensions and a very fair degree of perfection in Australia. Although, up to the present, we have not produced sufficient for our own consumpt, but have had to draw largely on Java and Mauritius, the time is now rapidly approaching when more than the whole quantity required will be produced within our own shores, and our four millions of people will practically derive all their supplies of sugar—amounting to about 168,000 tons per annum—from their own home production.

I have less hesitation in laying before you an outline of the condition of this great industry in Australia, and of the general methods in use for the extraction of the sugar from the canes, when I reflect that almost the whole of the machinery used in the manufacture and refining of sugar in these colonies has come from the workshops of Greenock and Glasgow, and how intimately the industry concerns the Clyde district.

Although I am speaking nominally of Australia, my remarks will cover, not only it, but also New Zealand, Tasmania, and Fiji, which are usually embraced in the term Australasia. The whole of the sugar manufactured in Australia is the product of the sugar cane, whose cultivation is confined to Queensland, the north of New South Wales, and to Fiji, but it will doubtless in time extend to the tropical portions of the other colonies, such as the northern territory of South Australia. The cultivation of beet-root has at different times been initiated in some of the southern colonies, but it has never been a commercial success.

All the views to be shown are illustrative of the operations of the Colonial Sugar Refining Company, Limited, the largest industrial corporation in Australia, and one of the most progressive—having no less than ten sugar mills at work in Australia and Fiji, five refineries in as many different colonies. nd an eleventh mill now being built on the Isis scrub, Queensland. Of these mills, three are situated in Queensland, three are

in New South Wales, and four are in Fiji; while there is a refinery in each of the following colonies:—New South Wales, Victoria, South Australia, New Zealand, and Queensland. The first operation in connection with the production of sugar is, of course, the preparation of the land. The dense growth which in Australia covers the virgin soil has to be removed, and the land broken up and cultivated for the reception of the cane plants.

The first slide shown represented a general view of the Isis scrub; in the near foreground the dense growth of trees and bushes, termed scrub, had been cleared, while the untouched forest was seen beyond. Next there was shown the operation of clearing—the trees being cut down, allowed to dry, and then burnt off. By placing heaps of brushwood over the stumps previous to firing, these were burnt out. The next two slides showed further stages in the clearing; and then came a field of young growing cane, in which some tree stumps were still standing, and a number of South Sea Islanders, or, as they were called "Kanakas," employed in the cultivation, were seen in the field. In the next picture there was the camp scene, a typical example of camp life in the bush. The camp was pitched on the spot where the new Isis Mill is now being erected, and was occupied by the men engaged on the necessary preliminary operations.

Then was shown a view of Condong Mill, on the Tweed River, New South Wales. River-bank situations are chosen for the mills for convenience of transport of the cane, which can very cheaply be conveyed for great distances in the large open punts. where otherwise the cost of land haulage would be prohibitive, (The appliances embraced in this view were very numerous, and showed that the mill was thoroughly equipped.)

The punts used for the conveyance of the cane are open barges, built of iron, and capable of carrying 30 to 35 tons of cane. In the next two slides the building of these punts was shown. For the conveyance of the punts to and fro, steam tugs and launches are used, and the following slide gave a view of the little steamer *Eurella*, one of the launches at Condong Mill. That mill is fitted with a double-crushing plant, the cane between the two crushings being saturated with boiling water, a practice which is termed double-crushing, with maceration.

In another picture a view was given of the Company's Harwood Mill, on the Clarence River, New South Wales. The sacks of

raw sugar were seen being carried from the store in the mill and dropped into the hold of the steamer, for conveyance to the refineries. When the mill is at work, the interesting sight may be witnessed of the double stream of cane going in from the punts and the line of sacks of sugar going out to the deep-sea steamer. Harwood Mill has two double-crushing plants, and is thus just double the capacity of Condong.

The remaining New South Wales mill—the largest in the Company's possession, and said to have the largest working capacity of any yet built—is Broadwater Mill, on the Richmond River. Within the last few years this mill, a view of which was now shown, has been entirely rebuilt and remodelled, and is now as modern and well equipped as any sugar mill in existence. It has three double-crushing plants, of the same type as those at Harwood and Condong.

One of the latest appliances in connection with the crushing operation is the "cane shredder," a machine which is fitted in front of the cane mill. Its purpose is to submit the cane to a preliminary shredding or tearing operation, a treatment which greatly aids the subsequent crushing, enabling better extraction to be done with less addition of maceration water. A shredder in the workshop, ready for sending to be erected at the mill, was shown in one of the views.

In several of the following pictures views were given of the crushing mills and their engines, the "megass" mill, the clarifiers (in which the juice is dealt with), the vacuum *triple effèt* apparatus, and the centrifugal machines (in which the grained sugar is separated from the molasses).

Next in order came a view of Homebush Mill, which is situated at Mackay, in North Queensland. It afforded some notion of the difficulties involved in the erection of a large mill in the wilds of Queensland. The picture illustrated the conveyance of the bottom part of a multiple-evaporating plant by bullock teams from the seaboard to the mill. This piece of machinery required for its conveyance a team of 42 bullocks, and it was carried on a specially-built wagon.

At a later stage were shown two views of Victoria Plantation, in North Queensland, under different conditions. In the first there were seen the fields of cane, with a bridge over a creek; then there was the same scene in flood-time, in which bridge and fields were submerged, and a gang of "Kanakas" were busily

engaged endeavouring to push off a floating island to prevent damage to the bridge. These curious floating islands are composed of dense masses of vegetation, often with fair-sized trees growing on them, and are washed down by floods, and frequently carried right out to sea.

Several slides followed which showed other difficulties that are encountered in flood-time, and the use of locomotives for land traction where the mills are not situated on navigable rivers.

At Goondi Mill, Johnstone River, Queensland, of which a picture was shown, Javanese are largely employed, and a picture of a typical group of these people was projected on the screen. At all the Company's establishments the whole operations are conducted under close chemical supervision, there being an efficient chemical staff and laboratory. The chemical laboratory at Goondi Mill was shown in illustration.

It is rather difficult to get a clear photograph of growing cane, because of the density of the close-growing stalks, but a view was given of a few isolated plants growing in the experimental nursery which is conducted at Goondi Mill. It gave a fair idea of the appearance and character of growing cane. A view of the hospital attached to Homebush Mill having been shown, leave was taken of Queensland, and then a considerable number of slides were "screened" to illustrate the Company's mills and plantations in Fiji, where the labour employed is mainly that of Indian coolies.

Most of the remaining pictures were illustrations of the Company's refineries. They were chiefly intended to show some special features or processes at the Pyrmont Refinery, Sydney (which is the Company's principal establishment of the kind); the Chelsea Refinery at Auckland, New Zealand; Yarraville Refinery, Melbourne; Glanville Refinery, Adelaide; and the New Farm Refinery at Brisbane, the most recent of them all, having started work a little over a year ago.

XIV.—*The New Rules by the Board of Trade as to Colour Testing for Mariners and Railway Servants.* By Freeland Fergus, M.D.

[Read before the Society, 3rd April, 1895.]

With Coloured Plate.

Two years ago I had the honour to read, before the Philosophical Society, a short paper on the "Light Sense in its relation to Navigation." In that paper I took occasion to suggest that the danger of that form of defective vision, generally known as congenital colour-blindness, sometimes called "Daltonism," was not, to any great extent, a serious danger to navigation, and that of late years the supposed danger had been unduly magnified. To-night I wish to devote almost the entire time at my disposal to this aspect of the case, for I cannot but feel that grave injustice has been done to many seafaring men by the regulations lately issued by the Board of Trade. There is presumably no person who does not desire everything in reason and equity for the public safety, and when it is proved that a man has a defect which renders it dangerous that he should occupy a certain position, then, of course, public safety may demand that he should not be allowed to hold it. It is because I believe that the vast majority of colour-blind persons can distinguish perfectly between a port and a starboard light that I have ventured to trespass on the time of the Society. Fortunately my argument is an appeal to facts. I do not think that it is material to the point that I have no theory of colour-blindness, and do not see my way to accept either the Young-Helmholtz theory or that of Hering. These are questions which do not necessarily form part of our investigations, and that is just wherein the Report of the Committee of the Royal Society on Colour Vision, and the more recently published book by Captain Abney, have made a radical mistake. They have assumed that the Young-Helmholtz theory is accurate; at any rate, they are written on the assumption that the Young-Helmholtz theory is the one most probably true.

We cannot too much admire the efforts of the physicists and physiologists who have striven to maintain the truth of the Young-Helmholtz theory. It was the theory on which I myself was brought up by that very learned man, the late Professor Donders,

of Utrecht, and I was for a whole summer engaged with him in examining persons for colour-blindness. The instrument which he then employed was a spectroscope, giving two spectra, placed one above the other. Any portion of the one spectrum could be shut off from the rest and compared with any selected portion of the other; moreover, any portion of the upper spectrum could be placed over any selected part of the lower. In addition, the same source of light was used for the two spectra, but the amount forming each could be regulated at will. Thus, it will be seen that, to a limited extent, Donders' instrument fulfilled some of the purposes for which the splendid apparatus designed by Abney, and described at length by him in his small book on colour measurements, was contrived.

Briefly stated, the Young-Helmholtz theory is as follows:—There are three primary colour sensations—namely, a red, a green, and a dark blue. Thus, by mixing red with green in different proportions, we get the various shades of orange and yellow. Green, mixed with the blue sensation, will give us the various greenish blues; and the blue sensation, mixed with the red, will give us the purples. So far so good: all observers, moreover, are of opinion that no admixture of colours will give us red or green or this primary blue. This was an observation confirmed by Donders, and is also repeated by Abney in his recent and most excellent book on colour vision. Let this be granted, although I am not sure that so much can be granted, for I am not personally aware that any experiments have been conducted on the mixtures of the colours forming the visible parts of the spectrum with those parts which are invisible—namely, with the rays known as the caloric and actinic. The mixture of these rays with the rays of the spectrum which are visible must, of necessity, produce some change in the latter, and it has not yet been proved, so far as I am personally aware, that, for example, green cannot be formed by the admixture of one of the visible colours with one of the invisible. Let it, however, be granted that there are three primary colour sensations, or, at any rate, that there are three colour sensations which cannot be produced by the admixture of any two of the visible rays. The Young-Helmholtz theory, as is well known, predicates that in each of the retinal elements there is what may be called an end organ capable of responding to one, and only to one of these sensations. Thus, when we see a yellow, it is because the end organ for red and the end organ for green are stimulated

together. If the red is stimulated more than the green, then the resultant is an orange sensation. I need not take up the time of the meeting with further details; particulars of the theory can be obtained in any good text-book of physiology, and a masterly exposition of it can be had in the writings of the late Professor Donders. The objections to this theory are in some respects too technical to be dealt with satisfactorily on this occasion. Still one or two of them may be readily understood.

It is a mistake to talk in a physical sense of primary colours. We only know that a colour is the mental interpretation of a wave frequency. Moreover, in the frequencies of light there are not, as in sound, any which are multiples of others; there is nothing corresponding to the octave in music. Again, we have no consciousness that any colour is of more importance than another when we look at the spectrum. We can distinguish a series of colours, but no one can be said to be a primary sensation and another not. One very important objection is the fact that at the periphery of the retina only two colours are recognised. If, then, it takes at the centre of the field of vision corresponding with the centre of the retina three sensations to make white, it stands to reason that in that part of the retina where only two colours are recognised we have only two colour sensations. In this part, therefore, white, as seen with the centre of the retina by the supposed three sensations, should not appear the same at the periphery of the retina, but should appear coloured, unless these two colour sensitivities are complementary to each other. Now, so far as we observe the tone of a piece of white paper, it does not alter as it is brought over the field of vision. To us, also, the fact that any two complementary colours always make up white is most suggestive.*

Although to our own mind these objections almost preclude the truth of the theory of Young and Helmholtz, we are too well aware that they will not satisfy the partisans of this theory. We must turn to others. And, first, there have not been shown to exist in every cone of the retina three terminals corresponding to the three colour sensations. True it is that Cajal has lately pointed out that each cone is connected with several nerve fibres, but, so far as I know, there have not been proved to exist three

* For a more detailed account of the objections to the Young-Helmholtz theory, reference may be made to the Address of Professor Rutherford at the Meeting of the British Association, held in Edinburgh in 1892.

terminals in each retinal cone. So far as that goes, every cone seems to be capable of receiving and transmitting all the colour sensations indifferently. It is highly probable that the same cone responds differently to the several energies of the various coloured lights. There is nothing to prevent it. No one supposes that a different ether is required to transmit the different colours in space, and I, for one, do not see the necessity of supposing that there is any need of three terminals to transmit the sensation of waves of light to the brain. Yet if the Young-Helmholtz theory be true, every cone must have three terminals, or else for every sensation of white light three cones must be employed. We know for a fact that one cone is sufficient to record the sensation of white, and there is no anatomical or physiological proof whatsoever that it is not capable of recording every other.

But, further, the usually-accepted view of the Young-Helmholtz theory is entirely disproved by the experiments of what may be called complementary simultaneous contrast. If, with a lantern, we project a pencil of red light on a screen, then, on placing an opaque body in the red light, the shadow which it casts on the screen is, as is well known, the complementary green. Now the congenitally colour-blind see no difference between the colour of the light and the colour of the shadow. That is a circumstance somewhat difficult of explanation on the Young-Helmholtz theory.*

Interesting as such considerations are, they do not by themselves prove what I wish to establish—namely, that colour-blind persons may safely be entrusted with the duties of navigation, provided they can distinguish between a port and starboard light, and that, therefore, the new rules are, to a considerable extent, oppressive and unnecessary. I propose to show that there is no reason to suppose (1) that the majority of colour-blind persons cannot distinguish between a port and starboard light; (2) that a large number of colour-blind persons have in the past navigated, and apparently with perfect safety; (3) that there is little evidence that any damage has in the past arisen from this defect. Thereafter I shall make a few remarks as to the question in general, and, if time permit, I shall refer to defective light sense, which I still think is a much greater danger than a defective colour sense.

* We would at least expect that the other colour sensation would affect the result.

First, then, it will be my endeavour to show that the majority of colour-blind persons can distinguish between a port and starboard light. Be it observed that I have carefully used the word "majority," for I believe that there are a very insignificant minority who cannot do it. There may in these cases be some danger, but certainly it is most unfair to class all cases as alike dangerous.

To begin with, I have had recently brought before me two young men (and they are, I know, types of the majority), who, having been for several years at sea, have never once in the whole course of their experience mistaken a single light. Yet by the new rules of the Board, they are both deprived of further promotion. One of them tells me that many a time in dirty weather he has been roused from his bed, when off duty, to pick up lights. I am told by their employers that they have completely satisfied the shipmasters with whom they sailed, who personally never once doubted from their own observations that the lads in question had not normal sight. Yet because they have some difficulty with greens, and confuse with green in one case a dark grey and in another a buff, they are both put ashore. Neither of them ever for a moment in arranging Holmgren's test wools had the slightest difficulty about the reds. They could not, however, classify greens, but never confused green with red. It is, therefore, perfectly evident that these two lads could quite well distinguish between a port and a starboard light, which are coloured. Their case is, I know, quite similar to that of very many others.*

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* Since making this communication to the Philosophical Society, the following case has come under my notice:—Neil M'Millan, apprentice, has been four years at sea. He has been refused a second mate's certificate on the ground that he is colour-blind. On the 17th of April, 1895, he was examined in my room in the presence of Dr. George Edington. He states that he has been four years at sea, and has never yet mistaken a light. In my room he had not the slightest difficulty as to red. He confused greens with drabs, but never for a moment confused green with red or with a reddish colour. On my suggestion, he saw the master of the ship on which he had served his apprenticeship, and he at once granted him the following testimonial:—

"Ship *M'Millan*, Glasgow, 18th April, 1895.—This is to certify that Neil M'Millan has served his time under my command. During the whole time of his apprenticeship I have never known him to make a mistake in distinguishing between red and green lights.—(Signed) Robt. Guthrie, Master."

Those who exaggerate the danger of colour-blindness may naturally decline to accept such a statement. It is necessary to take other evidence. This, fortunately, is supplied to us by a recent Parliamentary return. This is the report on the colour examinations for 15 months, ending with August 31st, 1894, and is the last report based on the old examination by means of coloured cards and coloured glasses. From that return I learn that during these 15 months six men who held second mates' certificates came up for re-examination and were rejected. Their average of sea service was *eight* years.

Similarly eight men who held first mates' certificates were rejected after having an average of 14 years' sea service. Four masters who came up for colour examination were rejected, and that with an average of 24 years' service. In one aspect the report is most defective, in respect that no mention whatsoever is made as to whether or not any of these persons had ever been responsible for any serious accident. If the theory of colour-blindness is true, then surely we have here ample material to give us a large number of misfortunes. No mention, however, of any such thing is made. It is therefore not wide of the mark to conclude that, up to the time of these examinations, these ships' officers had navigated with perfect safety and had never mistaken one of the lights for the other. That, I think, proves our case conclusively.

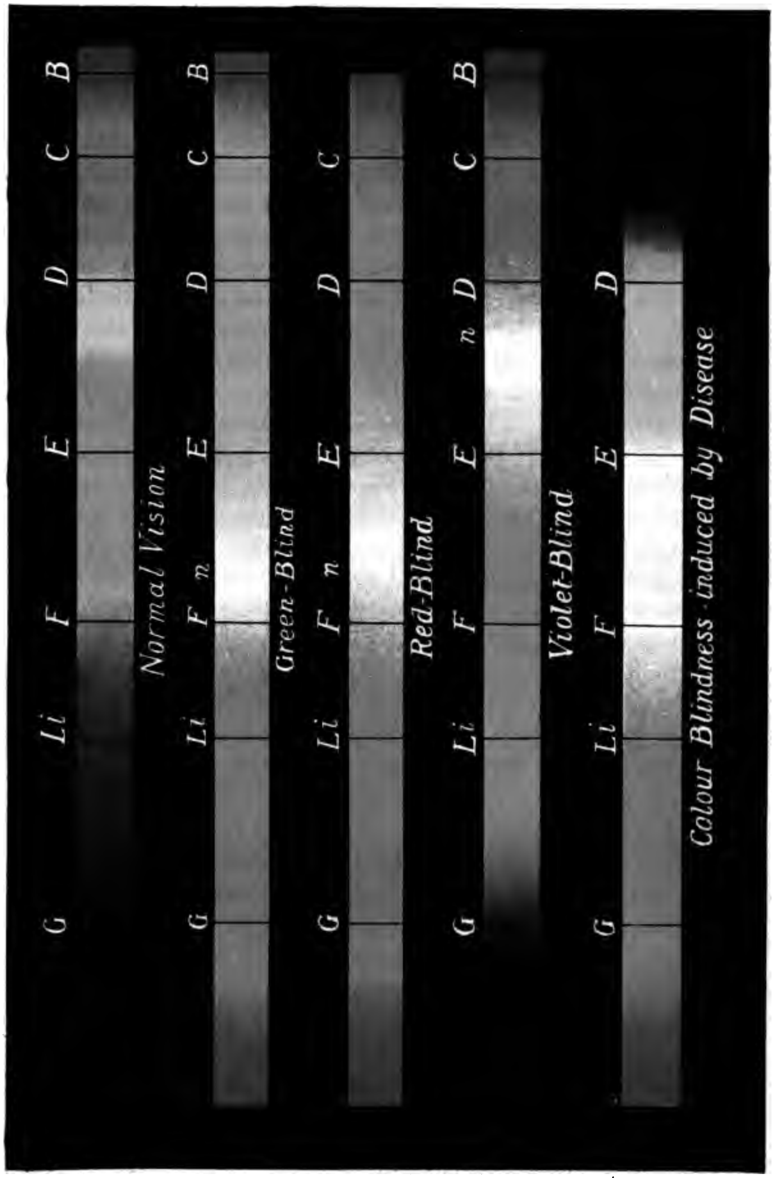
But here the question naturally arises: If these men have had defective colour sense, how is it physically possible for them to distinguish between a red and a green? It seems to me that there are only three possible explanations—(1) The colour-blind person has, as a rule, a perfectly normal light sense. The one light will therefore appear to him not merely relatively brighter than the other, but absolutely so. If it were not that the eye has the power of estimating brightness apart altogether from considerations of distance, then navigation would be impossible even to the most normally sighted person. (2) I consider it just possible that the colour-blind may be able to distinguish between the thermal effects of the different portions of the spectrum, although on this point I do not lay great stress. (3) Although the colour-blind do not see the spectrum as normal persons do, yet it is certain that the different portions of it have not only different luminosities, but also, even to the colour-blind, different colours. Let us take the spectrum as seen by the colour-blind,

and we cannot take it from a higher authority than from Captain Abney. In his book we have a diagram of the spectrum as seen by the normal eye, another representing the spectrum as seen by a red-blind person, another representing the spectrum as seen by the green-blind, and a fourth showing the spectrum as seen by those who are colour-blind from disease. By the kind permission of Captain Abney, the coloured diagram is reproduced to illustrate this paper. (See Plate.) These spectra are the same as those issued in the Report of the Royal Society's Committee, 1892. It is very difficult to say how far they are correct, and how far they accurately represent the colours as seen by the colour-blind. Neither Captain Abney nor the Committee of the Royal Society give us any indication of how they arrived at these diagrams, and to a considerable extent they seem to be theoretical. Granting that the red-colour-blind spectrum is correct, it is quite obvious that a so-called red-colour-blind person can readily distinguish between the two lights. The port light is made of red glass, whose wave-length, as nearly as possible, corresponds with the C line of the spectrum. The green or starboard light, on the other hand, is taken from the portion rather to the right of the F line of the solar spectrum. It is at once obvious from a glance at the diagrams that in every case the colour-blind can see a difference in hue between the colour at C and that at F. Therefore, these very diagrams bear out my statement that the colour-blind, as a rule, can tell a port from a starboard light. So long as a man can do that, he is perfectly safe on the bridge.*

My next proposition is that in the past very many colour-blind persons have navigated with safety. It is admitted on all hands that if you take a given number of male persons you will find four or five per cent. of them to be colour-blind. Now, in the days before there were any examinations at all, as regards colour vision, four to five per cent. of the vessels going to sea must have been navigated by colour-blind persons, for at least four or five per cent. of the officers must have been colour-blind. I have yet to learn that till recently four or five per cent. of all the ships at sea were lost from collision; still if the danger is as it is represented to be, then we would expect to find that at least four or

* In fact, so long as he is perfectly certain about one light, he is safe, for he knows the other is not that one.

Illustrating Dr. Fergus's Paper on Board of Trade Rules as to Colour Testing.



Copied by permission from Captain Abney's Book on Colour Blindness

Maclure, Macdonald & Co.

five per cent. of all vessels were liable to be lost annually by a collision or by some other accident depending on a mistake of colour. It cannot for a moment be doubted that no such record of disaster is to be found. In this aspect it is much to be regretted that the Parliamentary return already referred to does not contain information as to the accidents which have already happened to the officers rejected. In the main it is to be inferred that they never met with any accident from colour-blindness. Such an occurrence would have proved a perfect godsend to those who have run the theory of danger to death, and those of us who hold the opposite view would have heard plenty about it before now.

I happened also to analyse, for my own information, the report issued before the one under discussion. Unfortunately, the exact details of it are not before me at present, but I remember this fact, namely, that the average sea service of the officers rejected was, as nearly as possible, thirteen years. Now, it seems to me that, if a man has picked up lights correctly for a period of thirteen years, there is every chance that he will continue to do so in the future. The report preceding that for the period ending 31st August, 1894, is also silent as to accidents having occurred to those persons who were found to be colour-blind. I cannot but think that in this whole subject there has been something like giving the dog an ill name and then hanging him.

But, thirdly, assuming that colour-blindness occasionally causes accidents, there is little or no direct evidence that it has produced such a number of accidents as it must have led to had the danger been so great as has recently been supposed. At the time of the report by the Committee of the Royal Society only one very doubtful case was in evidence, and several of the witnesses of the widest experience said that they never had heard of such a thing. The doubtful case referred to was that of the *Iron Duke*, which is so well known as not to need further discussion. I do not think that it was ever proved absolutely that colour-blindness was the cause of that catastrophe. Were it admitted, what then? It merely shows that one out of the many thousands of casualties was due to this defect. I have already stated that the large majority of colour-blind persons can navigate with safety; I have never said that every person so affected is safe; but I strongly hold that it is most unfair to class the safe with the unsafe. There is a limit, and it ought to be the endeavour of

such self-constituted authorities as the British Medical Association's Committee to define the limits of safety, and not to urge that all colour-blind persons are alike dangerous.

Turning to the recently published book by Captain Abney, I cannot find any great array of facts to prove the existence of the danger. Any view expressed by Captain Abney is worthy of all respect, for not only is he a most competent authority on all points regarding the physics of light, but he is in all respects a most trustworthy man. I, therefore, opened his book expecting to find a whole array of facts to prove that my suspicion that the danger of a defective colour sense had been exaggerated was untrue. Here, however, is what he says on the subject:—"The question of colour-blindness is one of very practical importance, as in certain occupations it is essential that colours should be accurately and quickly known, and that no guess work should be allowed. Lives have without doubt been lost by a want of proper knowledge of colours, both at sea and on railways." Then follow these important words:—"The evidence that such is the case is, as a rule, it is true, merely negative, though there are cases extant where great losses which have occurred can be traced to a deficiency in colour perception." Now, is it unreasonable that details should be asked for? To my mind it is the most obvious question possible. Yet on these very details, which might or might not support the danger theory, no information is given. If the thing is of such frequent occurrence, surely it would be possible to give, without much trouble, examples to the extent of, say, a hundred or so. Till some such thing had been done, such stringent regulations as have lately come into force might have been withheld. I do not ask for anything unreasonable, I only ask for definite information.

To indicate still further to what an extremity the zeal for colour testing has gone, it may be mentioned that in some shipowners services all engineers and stokers are required to pass the test for colours—that is to say, to arrange Holmgren's wools. What would be thought of the sanity of any British matron who, before engaging a cook, insisted that she should undergo a thorough examination of her colour sense? Yet it is quite as important that a cook should have normal vision as that a stoker should have it. The thing seems, on the face of it, absurd to the last degree.

Furthermore, for every vessel which has been in collision from those in charge of it being colour-blind, or for every train that has been in an accident from the same cause, there have been a

very much greater number of vessels lost and trains wrecked from an over-indulgence in alcohol. To have that consistency which is looked for naturally in a Government department, we would expect to find that the Board of Trade would insist on all persons who are engaged in navigation, or who are responsible for the correct giving and interpreting of railway signals, to refrain from an over-indulgence in alcohol, if not to be total abstainers of approved standing. No such regulation, however, as the latter is in force. The danger from alcohol is a much more real one, and a much more frequent one than the danger from colour. Put the two cases as a parallel. The Board of Trade do not take his certificate from a man merely because he is of intemperate habits, although all past experience makes it probable that he will likely run himself and others into danger, if not into disaster, while they prevent a man who is colour-blind getting one at all, although there is very little evidence to show that it is at all likely that such a man will ever have a mishap. The Board have, no doubt, most difficult duties to perform, and all we wish, however, is that there should be a certain amount of equality in their dealing.

This, then, concludes all that is to be said at present on the propositions which I have called primary. There are other matters which must now take up our attention.

And, first of all, it may naturally be asked, what is the limit of safety, and who amongst the colour-blind can be trusted? My practical answer to that is, that I would grant a certificate of competency to every one who was able to distinguish, without the least hesitation, between a port and a starboard light. If there is any doubt as to a candidate's fitness, let him be sent to sea with some master in whom perfect confidence can be placed, and let this master report as to how many times he has made mistakes at night. Let even one mistake disqualify. Were this done, I feel satisfied that a large number of those who are now being rejected would be found competent. In the same manner, I would allow a man to be employed on the railway so long as he is able to tell the red signal from the green one. Of course, if there is absolutely trustworthy evidence that a candidate has for years been able to distinguish between a port and a starboard light, then I am not sure that I would insist on his being put to these preliminary trials at sea; but the evidence accepted would require to be of the very strongest and most reliable kind. The old tests

employed up to the 1st of September last were very much of this description, but, owing to the report of the Committee of the Royal Society, Holmgren's wool tests have been all but universally adopted in this country; no one now can get a certificate from the Board of Trade without passing an examination in them. Let us suppose that the signals to be interpreted were the differences between a high and a low note. In that case would it be requisite that before a man received a certificate of competency to interpret these signals, he should be asked to tell when a violin was in tune. This is almost precisely similar to what has been done in the case of colour. To show that the Board of Trade test is not at all a fair one, I think it may interest the Society to hear the results of an examination which I made the other day on Mr. George Henry, A.R.S.A., whose brilliant powers as a colourist are universally known by all interested in Scottish art. He first of all described the spectrum very accurately, referring the colours very exactly to the scale which was shown along with it. I next showed him Holmgren's wools spread out on a white background, and asked him to arrange them. He at once said that, to him, it was almost impossible. To help him out of the difficulty, I picked out one of the test skeins, and I asked him to select from the wools all those which were similar. I have much pleasure in showing you, with his permission, his selection.* I feel perfectly sure that any of the local examiners in Scotland would have at once rejected a man who made a similar choice. Yet probably there is no one with a sharper colour sense. Mr. Henry sees the same prevailing colour in each of these wools, although a less highly-trained eye cannot see that they have any features in common.

This leads me now to a matter of very great importance to all officers and men employed at sea or on railways. The Board of Trade have for many years back sanctioned examinations which they now affirm were inefficient. Personally, although I believe that these examinations were incomplete for the detection and study of colour-blindness, from a physiological point of view, still I am very strongly of opinion that they were quite adequate tests as far as

* Mr. Henry was given a somewhat dark pink. He selected as similar all the lighter pinks, and a few colours which, to the ordinary observer, seemed grey. On being questioned on the subject, he said that in all there was the same pigment diluted with different amounts of white light. Although his statement was probably quite true, yet I feel certain that he would have been rejected at a marine examination.

mere safety was concerned. What has been the consequence of the change? It is this, that a number of men have not only begun, but have gone a very considerable way in, a professional career, relying on the Board of Trade certificate that they were fit as regards eyesight to do so. The Board of Trade now turn round and say that their own tests were not at all efficient, and that these men must retire from the sea and give up their means of earning their living. I may be wrong, but my decided opinion is that these are cases which should be compensated by Government.

But, further, till very recently, if a man was being examined for a captain's certificate, and, while being so, he was found to be colour-blind, it was noted on his certificate that he had failed to pass the colour examination. A man with such a certificate generally could get employment other than that of actual navigation, for which a certificate of that nature was necessary. For example, he might be appointed a harbour-master or a ship's husband. Moreover, some firms would give such a man command of a ship, and provided that they had, from previous experience of him, confidence in his powers of distinguishing lights, they were quite right. I understand that now such certificates are withheld altogether, and, therefore, the sailor is left stranded, without any means of making his living. Several men have recently been thrown out of employment, and have, at an advanced period of life, to begin the world over again. These cases, I think, urgently demand compensation. Of course, if a man has gone to sea to serve his apprenticeship without taking the precaution to have his sight examined, he is there at his own risk; but if he has once passed the Board of Trade examination, thereafter the Board of Trade are responsible for him, and if at a subsequent stage he is found to be congenitally colour-blind, and is prevented from further promotion in his profession, then I certainly think that ample compensation is due to him. He is placed in a very awkward position, and that through no fault of his own.

But why have the Board of Trade awakened so thoroughly to a sense of the danger of colour-blindness? It is, I think, largely due to the fact that ophthalmic surgeons have for a number of years kept dinning into the ears of the Board as to the danger of the defect in question. These surgeons have tacitly taken it for granted that any form of colour defect is dangerous, and have proceeded on this erroneous assumption. I have no doubt that

there are dangerous forms of colour-blindness—for example, monochromatic colour-blindness, and a few other forms, but I am quite sure that the larger number of colour-blind persons are perfectly safe. In the writings of the ophthalmic surgeons referred to, there is the same absolute want of proof in so far as the specification of actual cases is concerned. Moreover, some of them are profoundly ignorant of the conditions of sea life. When I made my previous contribution to the proceedings of the Society, a writer in one of the medical papers was good enough to mention with approbation my suggestion, that the light sense was of great importance, saying, at the same time, that the idea was entirely new. He deprecated, however, very strongly the notion that the colour-sense danger had been exaggerated. To soothe his feelings, I wrote to say that probably it were well to have all officers on whom the ultimate interpretation of lights depended carefully examined. I at once received a letter saying that surely I would in all cases require the steersman also to be tested. His ideas of sea duties must have been taken from a Thames barge, otherwise he would have known that any man who took his eyes off the binnacle to look about for lights would very properly be put ashore at the first convenient moment. Till steam-steering was invented, the duties of quartermaster were generally performed in a house at the extreme after-end of the ship.

But suppose the tables were turned; suppose that the Shipmasters' Association were to take as disinterested a view of the ophthalmic surgeons as these gentlemen have taken of them, then we would see some changes. Surely it would not be too much to insist that all gentlemen who practise ophthalmic surgery should have some knowledge of the science of light, especially if they aspire to test candidates for the Board of Trade. What would be thought were the Shipmasters' Association to petition the General Medical Council to pass a resolution that before a man was allowed to call himself an ophthalmic surgeon he should have a competent knowledge of Preston's Light, and a practical knowledge of such instruments as the optical bench, the spectroscope, and the spectrometer? There would certainly be nothing at all unreasonable in such a request. Not long ago I was perusing a book on colour-blindness written by a surgeon. I thought I had seen his remarks on the physical aspect of light somewhere before. On turning up Ganot's "Physics," I found that two paragraphs had been transferred from that excellent

book to the pages of the author, and without the usual inverted commas. I do not wish to be misunderstood. Many of the ophthalmic surgeons are in this department of work extremely efficient —I could mention a large number of them; but what I object to is that gentlemen who have not this preliminary necessary knowledge should pose as authorities on vision when, as a matter of fact, they know little of the subject matter—the science of light. It would just be as fair for the shipmasters to take an interest in their condition of knowledge as it is for such men to be signing petitions as to the eyesight of shipmasters and others.

This, then, concludes what I wish to-night to bring before the Philosophical Society of Glasgow. Something might be said on other aspects of the question. Particularly, perhaps, something ought to be said on the question of those men who in their younger days pass the form test, but who, from an error of refraction are quite sure to fail to do so as soon as their accommodation gives out at the age of forty or sooner. That certainly is a most important question, and merits serious consideration. If a man has such an error he ought not to go to sea at all, and it would be well to have those who intend going to sea tested, first of all, as regards their refraction. It ought to be remembered, however, that every navigating officer freely uses a field glass on the bridge. For railway men, I would let a man continue to drive his engine so long as he can at a standard distance see the semaphore, and has no hesitation as to the green and red signals.

Before closing, let me again reiterate that my own opinion is that the light sense is of as great importance as the colour sense. To estimate the light sense, I have lately devised a small instrument, which seems to give good results.*

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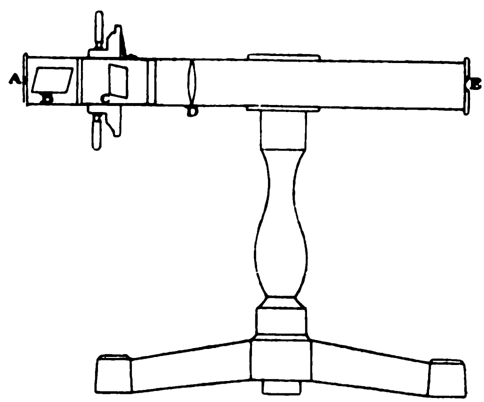
* Description of Instrument.—The instrument which I have devised for the measurement of the light sense consists of the following parts :—At A (see next page) is a small opening, through which a narrow beam of light reaches a Nicol's prism placed at B. The light transmitted by the prism is polarised. At C is placed a second Nicol's prism, which can at pleasure be replaced by a piece of Iceland spar. At D is a biconvex lens, so placed as to magnify the spot of light. The first Nicol's prism is made to rotate round the long axis of the tube. Let us suppose now that the second "Nicol" is placed at C. For a certain position of that prism no light passes ; there is darkness. The patient now places his eye at E, and the surgeon slowly rotates the "Nicol" in one direction till the patient indicates that he sees light. He then rotates it in the other direction till light is also perceived. The two points are carefully noted, and the angular displacement between them

Mr. President and Gentlemen,—I sincerely trust that I have not intruded too much on the time of the Society. Many cases which have lately been brought under my observation have convinced me that a grave injustice has been done. Medical men should, as a rule, confine their discussions to their own societies; but as this subject is not at all strictly a medical one, and as I felt sure that it was more properly one for the Philosophical Society than for any other with which I am connected, I have ventured to bring the matter here, in the hope that a discussion by others well qualified to express an opinion might amplify what has been, perhaps, a not very thorough review of an important subject.



is easily read in degrees by means of a scale attached to the instrument. This tests the smallest amount of light of which the patient is conscious.

In the next place, the "Nicol" at B is set so as to allow of all the light passing. A bright spot of light is now seen by the observer. The surgeon turns the prism at B, first in one direction, till the patient indicates that the spot is darker than it was at the first. He then turns it in the other direction till a similar observation is made. Patients with a defective light sense will not observe any change as rapidly as those who are in this respect normal.

Lastly, the piece of Iceland spar can be substituted for the second "Nicol." This gives in a certain position two spots of light of apparently equal intensity. By rotating the first "Nicol" one of the spots begins to decrease in brightness, and the other to increase. On rotating the "Nicol" at B, first in one direction and then in the other, we get a measure of the light-difference sense. No instrument for such investigations can take into account the personal equation of the patient. To avoid error, so far as is possible, a constant and equally illuminated source of light is used.

XV.—*On the Temperature Variation of the Thermal Conductivity of Rocks.* By LORD KELVIN, *P.*R.S., and J. R. ERSKINE MURRAY, B.Sc., 1851 Exhibition Scholar.

[Communicated to the Society, 27th March, 1895.*]

§ 1. The experiments described in this communication were undertaken for the purpose of finding temperature variation of thermal conductivity of some of the more important rocks of the earth's crust.

§ 2. The method which we adopted was to measure, by aid of thermoelectric junctions, the temperatures at different points of a flux line in a solid, kept unequally heated by sources (positive and negative) applied to its surface, and maintained uniform for a sufficiently long time to cause the temperature to be as nearly constant at every point as we could arrange for. The shape of the solid and the thermal sources were arranged to cause the flux lines to be, as nearly as possible, parallel straight lines; so that, according to Fourier's elementary theory and definition of thermal conductivity, we should have

$$\frac{k(\mathrm{M},\mathrm{B})}{k(\mathrm{T},\mathrm{M})}=\frac{[v(\mathrm{M})-v(\mathrm{T})]\div\mathrm{MT}}{[v(\mathrm{B})-v(\mathrm{M})]\div\mathrm{BM}},$$

where T, M, B denote three points in a stream line (respectively next to the top, at the middle, and next to the bottom in the slabs and columns which we used); $v(\mathrm{T})$, $v(\mathrm{M})$, $v(\mathrm{B})$ denote the steady temperatures at these points; and $k(\mathrm{T},\mathrm{M})$, $k(\mathrm{M},\mathrm{B})$, the mean conductivities between T and M, and between M and B respectively.

§ 3. The rock experimented on in each case consisted of two equal and similar rectangular pieces, pressed with similar faces together. In one of these faces three straight parallel grooves are cut, just deep enough to allow the thermoelectric wires and junctions to be embedded in them, and no wider than to admit the wires and junctions (see diagram, § 8 below). Thus, when the two pieces of rock are pressed together, and when heat is so

* The paper was subsequently communicated to the Royal Society (30th May, 1895), and is reproduced from the *Proceedings* of that Society by arrangement with Lord Kelvin.—*Ed.*

applied that the flux lines are parallel to the faces of the two parts, we had the same result, so far as thermal conduction is concerned, as if we had taken a single slab of the same size as the two together, with long fine perforations to receive the electric junctions. The compound slab was placed with the perforations horizontal, and their plane vertical. Its lower side, when thus placed, was immersed under a bath of tin, kept melted by a lamp below it. Its upper side was flooded over with mercury in our later experiments (§§ 6, 7, 8), as in Hopkins' experiments on the thermal conductivity of rock. Heat was carried off from the mercury by a measured quantity of cold water poured upon it once a minute, allowed to remain till the end of a minute, and then drawn off and immediately replaced by another equal quantity of cold water. The chief difficulty in respect to steadiness of temperature was the keeping of the gas lamp below the bath of melted tin uniform. If more experiments are to be made on the same plan, whether for rocks or metals, or other solids, it will, no doubt, be advisable to use an automatically-regulated gas flame, keeping the temperature of the hot bath in which the lower face of the slab or column is immersed at as nearly constant a temperature as possible, and to arrange for a perfectly steady flow of cold water to carry away heat from the upper surface of the mercury resting on the upper side of the slab or column. It will also be advisable to avoid the complication of having the slab or column in two parts, when the material and the dimensions of the solid allow fine perforations to be bored through it, instead of the grooves which we found more readily made with the appliances available to us.

§ 4. Our first experiments were made on a slate slab, 25 cm. square and 5 cm. thick, in two halves, pressed together, each 25 cm. by 12·5, and 5 cm. thick. One of these parts cracked with a loud noise in an early experiment, with the lower face of the composite square resting on an iron plate heated by a powerful gas burner, and the upper face kept cool by ice in a metal vessel resting upon it. The experiment indicated, very decidedly, less conductivity in the hotter part below the middle than in the cooler part above the middle of the composite square slab. We supposed this might possibly be due to the crack, which we found to be horizontal and below the middle, and to be complete across the whole area of 12·5 cm. by 5, across which the heat was con-

ducted in that part of the composite slab; and to give rise to palpably imperfect fitting together of the solid above and below it. We therefore repeated the experiment with the composite slab turned upside down, so as to bring the crack in one half of it now to be above the middle, instead of below the middle, as at first. We still found for the composite slab less conductivity in the hot part below the middle than in the cool part above the middle. We inferred that, in respect to thermal conduction through slate across the natural cleavage planes, the thermal conductivity diminishes with increase of temperature.

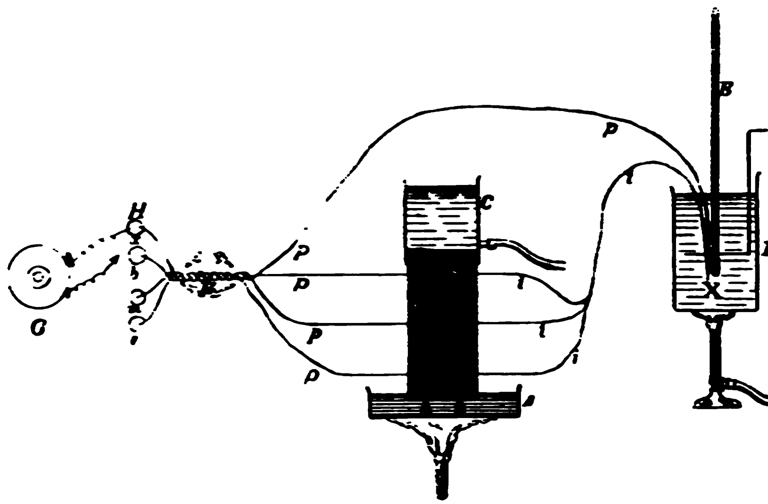
§ 5. We next tried a composite square slab of sandstone of the same dimensions as the slate, and we found for it also decisive proof of diminution of thermal conductivity with increase of temperature. We were not troubled by any cracking of the sandstone, with its upper side kept cool by an ice-cold metal plate resting on it, and its lower side heated to probably as much as 300° or 400° C.

§ 6. After that we made a composite piece, of two small slate columns, each 3·5 cm. square and 6·2 cm. high, with natural cleavage planes vertical, pressed together with thermoelectric junctions as before; but with appliances (§ 10 below) for preventing loss or gain of heat across the vertical sides, which the smaller horizontal dimensions (7 cm., 3·5 cm.) might require, but which were manifestly unnecessary with the larger horizontal dimensions (25 cm., 25 cm.) of the slabs of slate and sandstone used in our former experiments. The thermal flux lines in the former experiments on slate were perpendicular to the natural cleavage planes, but now, with the thermal flux lines parallel to the cleavage planes, we still find the same result, smaller thermal conductivity at the higher temperatures. Numerical results will be stated in § 12 below.

§ 7. Our last experiments were made on a composite piece of Aberdeen granite, made up of two columns, each 6 cm. high and 7·6 cm. square, pressed together, with appliances similar to those described in § 6; and, as in all our previous experiments on slate and sandstone, we found less thermal conductivity at higher temperatures. The numerical results will be given in § 12 below.

§ 8. The accompanying diagram represents the thermal appliances and thermoelectric arrangement of §§ 6, 7. The columns of slate or granite were placed on supports in a bath of melted tin

with about 0·2 cm. of their lower ends immersed. The top of each column was kept cool by mercury, and water changed once a minute, as described in § 3 above, contained in a tank having the top of the stone column for its bottom and completed by four vertical metal walls fixed into grooves in the stone and made tight against wet mercury by marine glue.



Iron wires are marked *i*.
Platinoid wires are marked *p*.
B, M, T. Thermoelectric junctions in slab.
X. " " oil bath.
A. Bath of molten tin.
C. Tank of cold water.
D. Oil bath.
E. Thermometer.
F. Junctions of platinoid and copper wires. The wires are insulated from one another, and wrapt all together in cotton wool at this part, to secure equality of temperature between these four junctions, in order that the current through the galvanometer shall depend solely on differences of temperature between whatever two of the four junctions, X, T, M, B, are put in circuit with the galvanometer.
G. Galvanometer.
H. Four mercury cups, for convenience in connecting the galvanometer to any pair of thermoelectric junctions.
x, *b*, *m*, *t*, are connected, through copper and platinoid, with X, B, M, T, respectively.

§ 9. The temperatures v(B), v(M), v(T) of B, M, T, the hot, intermediate, and cool points in the stone, were determined by equalising to them successively the temperature of the mercury thermometer placed in the oil-tank, by aid of thermoelectric cir-

cuits and a galvanometer used to test equality of temperature by nullity of current through its coil when placed in the proper circuit, all as shown in the diagram. The steadiness of temperature in the stone was tested by keeping the temperature of the thermometer constant, and observing the galvanometer reading for current when the junction in the oil-tank and one or other of the three junctions in the stone were placed in circuit. We also helped ourselves to attaining constancy of temperature in the stone by observing the current through the galvanometer, due to differences of temperature between any two of the three junctions B, M, T placed in circuit with it.

§ 10. We made many experiments to test what appliances might be necessary to secure against gain or loss of heat by the stone across its vertical faces, and found that *kieselguhr*, loosely packed round the columns and contained by a metal case surrounding them at a distance of 2 cm. or 3 cm., prevented any appreciable disturbance due to this cause. This allowed us to feel sure that the thermal flux lines through the stone were very approximately parallel straight lines on all sides of the central line BMT.

§ 11. The thermometer which we used was one of Cassella's (No. 64,168) with Kew certificate (No. 48,471) for temperature from 0° to 100°, and for equality in volume of the divisions above 100°. We standardised it by comparison with the constant volume air thermometer* of Dr. Bottomley with the following result. This is satisfactory as showing that when the zero error is corrected the greatest error of the mercury thermometer, which is at 211° C., is only 0·3°.

Reading.		Correction to be subtracted from reading of mercury thermometer.
Air thermometer.	Mercury thermometer.	
0°	1°·9	1·9
120·2	122·2	2·0
166·8	168·6	1·8
211·1	212·7	1·6
265·7	267·5	1·8

* *Phil. Mag.*, August, 1888, and *Edinb. Roy. Soc. Proc.*, January 6, 1888.

§ 12. Each experiment on the slate and granite columns lasted about two hours from the first application of heat and cold; and we generally found that after the first hour we could keep the temperatures of the three junctions very nearly constant. Choosing a time of best constancy in our experiments on each of the two substances, slate and granite, we found the following results:—

Slate: flux lines parallel to cleavage.

$$v(\mathrm{T}) = 50^\circ{\cdot}2 \text{ C.}$$
$$v(\mathrm{M}) = 123^\circ{\cdot}3.$$
$$v(\mathrm{B}) = 202^\circ{\cdot}3.$$

The distances between the junctions were BM $= 2{\cdot}57$ cm. and MT $= 2{\cdot}6$ cm. Hence by the formula of § 2,

$$\frac{k(\mathrm{M, B})}{k(\mathrm{T, M})} = \frac{73{\cdot}1 \div 2{\cdot}6}{79{\cdot}0 \div 2{\cdot}57} = \frac{28{\cdot}1}{30{\cdot}7} = 0{\cdot}91.$$

Aberdeen granite:

$$v(\mathrm{T}) = 81^\circ{\cdot}1.$$
$$v(\mathrm{M}) = 145^\circ{\cdot}6.$$
$$v(\mathrm{B}) = 214^\circ{\cdot}6.$$

The distances between the junctions were BM $= 1{\cdot}9$ cm. and MT $= 2{\cdot}0$ cm.

$$\frac{k(\mathrm{MB})}{k(\mathrm{TM})} = \frac{64{\cdot}5 \div 2{\cdot}0}{69{\cdot}0 \div 1{\cdot}9} = \frac{32{\cdot}2}{36{\cdot}3} = 0{\cdot}89.$$

§ 13. Thus we see, that for slate, with lines of flux parallel to cleavage planes, the mean conductivity in the range from 123° C. to 202° C. is 91 per cent. of the mean conductivity in the range from 50° C. to 123° C., and for granite, the mean conductivity in the range from 145° to 214° C. is 89 per cent. of the mean conductivity in the range from 81° C. to 145° C. The general plan of apparatus described above, which we have used only for comparing the conductivities at different temperatures, will, we believe, be found readily applicable to the determination of conductivities in absolute measure.

XVI.—*On the Electrification of Air.* By Lord KELVIN, *Pres.*R.S.

[Communicated to the Society, 27th March, 1895.]

§ 1. Continuous observation of natural atmospheric electricity has given ample proof that cloudless air at moderate heights above the earth's surface, in all weathers, is electrified with very far from homogeneous distribution of electric density. Observing at many times from May till September, 1859, with my portable electrometer on a flat open sea-beach of Brodick Bay in the Island of Arran, in ordinary fair weather at all hours of the day, I found the difference of potentials between the earth and an insulated burning match at a height of 9 feet above it (2 feet from the uninsulated metal case of the instrument held over the head of the observer), to vary from 200 to 400 Daniell's elements, or, as we may now say, volts; and often during light breezes from the east and north-east it went up to 3,000 or 4,000 volts. In that place, and in fair weather, I never found the potential other than positive, never negative, never even down to zero, if, for brevity, we call the earth's potential at the place zero. In perfectly clear weather, under a sky sometimes cloudless, more generally somewhat clouded, I often observed the potential at the 9-feet height to vary from about 300 volts gradually to three or four times that amount, and gradually back again to nearly the same lower value in the course of about 2 minutes.* I inferred that these gradual variations must have been produced by electrified masses of air moving past the place of observation. I did not remark then, but I now see that the electricity in these moving masses of air must, in all probability, have been chiefly positive to cause the variations which I observed, as I shall explain to you a little later.

§ 2. Soon after that time a recording atmospheric electrometer,† which I devised to show, by a photographic curve, the continuous variation of electric potential at a fixed point, was established at the Kew Meteorological Observatory, and has been kept in

* "Electrostatics and Magnetism," xvi., §§ 281, 282.

† "Electrostatics and Magnetism," Sir William Thomson, xvi., §§ 271, 292.

regular action from the commencement of the year 1861 till the present time. It showed incessant variations quite of the same character, though not often as large, as those which I had observed on the sea-beach of Arran.

Through the kindness of the Astronomer-Royal, I am able to place before you this evening the photographic curves for the year 1893, produced by a similar recording electrometer which has been in action for many years at the Royal Observatory, Greenwich. They show, as you see, not infrequently, during several hours of the day or night, negative potential and rapid transitions from large positive to large negative. Those were certainly times of broken weather, with, at least, showers of rain, or snow, or hail. But throughout a very large proportion of the whole time the curve quite answers to the description of what I observed on the Arran sea-beach 36 years ago, except that the variations which it shows are not often of so large amount in proportion to the mean or to the minimums.

§ 3. Thinking over the subject now, we see that the gradual variations, minute after minute, through so wide a range as the 3 or 4 to 1, which I frequently observed, and not infrequently rising to 20 times the ordinary minimum, must have been due to *positively* electrified masses of air, within a few hundred feet of the place of observation, wafted along with the gentle winds of 5 or 10 or 15 ft. per second, which were blowing at the time. If any comparably large quantities of negatively electrified air had been similarly carried past it is quite certain that the minimum observed potential, instead of being in every case positive, would have been frequently large negative.

§ 4. Two fundamental questions in respect to the atmospheric electricity of fair weather force themselves on our attention :—

(1) What is the cause of the prevalent positive potential in the air near the earth, the earth's potential being called zero?

(2) How comes the lower air to be electrified to different electric densities, whether positive or negative, in different parts?

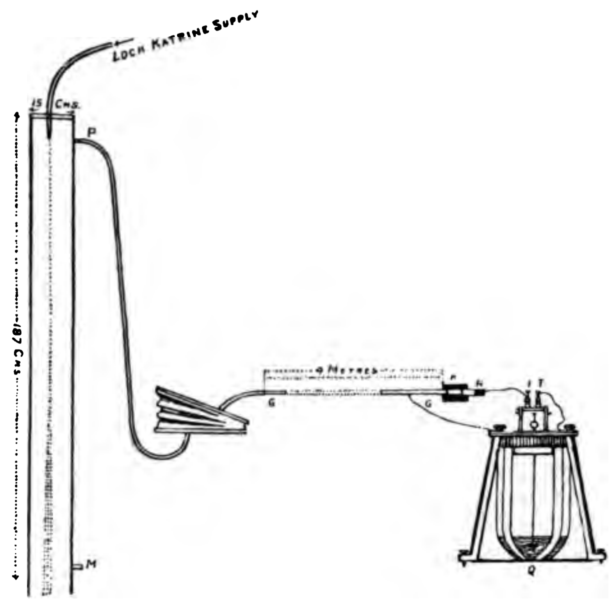
Observations and laboratory experiments made within the last six or eight years, and particularly two remarkable discoveries made by Lenard which I am going to describe to you, have contributed largely to answering the second of these questions.

§ 5. In an article "On the Electrification of Air by a Water-jet," by Magnus Maclean and Makita Goto,* experiments were described showing air to be negatively electrified by a jet of water shot vertically down through it from a fine nozzle into a basin of water about 60 centimetres below it. It seemed natural to suppose that the observed electrification was produced by the rush of the fine drops through the air; but Lenard conclusively proved by elaborate and searching experiments that it was, in reality, due chiefly, if not wholly, to the violent commotions of the drops impinging on the water-surface of the receiving basin, and he found that the negative electrification of the air was greater when they were allowed to fall on a hard slab of any material thoroughly wetted by water than when they fell on a yielding surface of water several centimetres deep. He had been engaged in studying the great negative potential which had been found in air in the neighbourhood of waterfalls, and which had generally been attributed to the inductive action of the ordinary fine-weather electric force, giving negative electricity to each drop of water-spray before it breaks away from conducting communication with the earth. Before he knew Maclean and Goto's paper, he had found strong reason for believing that that theory was not correct, and that the true explanation of the electrification of the air must be found in some physical action not hitherto discovered. A less thorough inquirer might have been satisfied with the simple explanation of the electricity of waterfalls naturally suggested by Maclean and Goto's result, and might have rested in the belief that it was due to an electrifying effect produced by the rush of the broken water through the air; but Lenard made an independent experimental investigation in the physical laboratories of Heidelberg and Bonn, by which he learned that the seat of the negative electrification of the air electrified is the lacerated water at the foot of the fall, or at any rocks against which the water impinges, and not the multitudinous interfaces between air and water falling freely in drops through it.

§ 6. It still seems worthy of searching inquiry to find electrification of air by water falling in drops through it, even though we now know that, if there is any such electrification, it is not the main cause of the great negative electrification of air which has been found in the neighbourhood of waterfalls. For this purpose,

* *Philosophical Magazine*, 1890, 2nd half-year.

an experiment has been very recently made by Mr. Maclean, Mr. Galt, and myself, in the course of an investigation regarding electrification and diselectrification of air with which we have been occupied for more than a year. The apparatus which we used is before you. It consists of a quadrant electrometer connected with an insulated electric filter* applied to test the electrification of air drawn from different parts of a tinned iron funnel, 187 centimetres long and 15 centimetres diameter, fixed in a vertical position, with its lower end open and its upper end



closed, except a glass nozzle, of 1·6mm. aperture, admitting a jet of Glasgow supply water (from Loch Katrine) shot vertically down along its axis. The electric filter (R in the drawing), a simplified and improved form of that described in the *Proceedings* of the Royal Society for March 21, consists of twelve circles of fine wire gauze rammed as close as possible together in the middle of a piece of block-tin pipe of 1cm. bore and 2cms. length. One end of it is stuck into one end of a perforation through a block of paraffin (K) which supports it. The other end (G) of this

* Kelvin, Maclean, Galt, "On the Diselectrification of Air:" *Proc.* R.S., March 14, 1895.

perforation is connected by block-tin pipe (which in the apparatus actually employed was $3\frac{3}{4}$ metres long, but might have been shorter) and india-rubber tubing through bellows to one or other of two short outlet pipes (M and P) projecting from the large funnel.

§ 7. We first applied the india-rubber pipe to draw air from the funnel at the *upper* outlet, P, and made many experiments to test the electricity given by it to the receiving filter, R, under various conditions as to the water-jet,—the bellows being driven as uniformly as the operator could work. When the water fell fairly through the funnel, with no drops striking it, and through 90cms. of free air below its mouth, a small negative electrification of R was in every case observed (which we thought might possibly be attributable to electrification of the air, where the water was caught in a basin about 90cms. below the mouth of the funnel). But when the funnel was slanted, so that the whole shower of drops from the jet, or even a small part of it, struck the inside of the funnel, the negative electrification of R was largely increased. So it was also when the shower, after falling freely down the middle of the funnel, impinged on a metal plate in metallic communication with the funnel held close under its mouth, or 10 or 20cms. below it. For example, in a series of experiments made last Monday (March 25th), we found ·28 of a volt in 15 minutes, with no obstruction to the shower; and 4·18 volts in 5 minutes, with a metal plate held three or four centimetres below the mouth of the funnel, the air being drawn from the upper outlet (P). Immediately after, with P closed, and air drawn from the lower outlet (M), but all other circumstances the same, we found ·20 of a volt in 5 minutes, with no obstruction; and 6·78 volts in 5 minutes, with the metal plate held below the mouth as before.

§ 8. These results, and others which we have found, with many variations of detail, confirm, by direct test of air drawn away from the neighbourhood of the waterfall through a narrow pipe to a distant electrometer, Lenard's conclusion that a preponderatingly strong negative electrification is given to the air at every place of violent impact of a drop against a water-surface, or against a wet solid. But they do not prove that there is *no* electrification of air by drops of water falling through it. We always found in every trial decisive proof of negative electrification, though of comparatively small amount when there was no obstruction to the shower between the mouth of the funnel and the catching basin, 90cms.

below it. We intend to continue the investigation, with the shower falling freely far enough down from the mouth of the funnel to make quite sure that the air which we draw off from any part of the funnel is not sensibly affected by impact of the drops on anything below.

§ 9. The other discovery* of Lenard, of which I told you, is that the negative electrification of air, in his experiments with pure water, is diminished greatly by very small quantities of common salt dissolved in it; that it is brought to nothing by ·011 per cent.; that positive electrification is produced in the air when there is more than ·011 per cent. of salt in the water; reaching a maximum with about 5 per cent. of salt, when the positive electrical effect is about equal to the negative effect observed with pure water; and falling to 14 per cent. of this amount when there is 25 per cent. of salt in the solution. Hence sea-water, containing, as it does, about 3 per cent. of common salt, may be expected to give almost as strong positive electrification to air as pure water would give of negative in similar circumstances as to commotion. Lenard infers that breaking waves of the sea must give positive electricity to the air over them: he finds, in fact, a recorded observation by Exner, on the coast of Ceylon, showing the normal positive electric potential of the air to be notably increased by a storm at sea. I believe Lenard's discovery fully explains also some very interesting observations of atmospheric electricity of my own, which I described in a letter to Dr. Joule, which he published in the *Proceedings* of the Literary and Philosophical Society of Manchester for October 18, 1859:†—"The atmospheric effect ranged from 30° to above 420° (of a heterostatic torsion electrometer of 'the divided-ring' species) during the four days which I had to test it; that is to say, the electrometric force per foot of air, measured horizontally from the side of the house, was from 9 to above 126 zinc-copper water cells. The weather was almost perfectly settled, either calm, or with slight east wind, and in general an easterly haze in the air. The electrometer twice within half-an-hour went above 420°, there being at the time a fresh temporary breeze from the east. What I had previously observed regarding the effect of east wind was

* "Ueber die Electricität der Wasserfälle," Table xvii., page 628. *Annalen der Physik und Chemie*, 1892. (Vol. 46.)

† Republished in "Electrostatics and Magnetism," "Atmospheric Electricity," xvi., § 262.

amply confirmed. Invariably the electrometer showed very high positive in fine weather, before and during east wind. It generally rose very much shortly before a slight puff of wind from that quarter, and continued high till the breeze would begin to abate. I never once observed the electrometer going up unusually high during fair weather without east wind following immediately. One evening in August I did not perceive the east wind at all, when warned by the electrometer to expect it; but I took the precaution of bringing my boat up to a safe part of the beach, and immediately found, by waves coming in, that the wind must be blowing a short distance out at sea, although it did not get so far as the shore. . . . On two different mornings the ratio of the house to a station about sixty yards distant on the road beside the sea was ·97 and ·96 respectively. On the afternoon of the 11th instant, during a fresh temporary breeze of east wind, blowing up a little spray as far as the road station, most of which would fall short of the house, the ratio was 1·08 in favour of the house electrometer—both standing at the time very high—the house about 350°. I have little doubt but that this was owing to the negative electricity carried by the spray from the sea, which would diminish relatively the indications of the road electrometer."

§ 10. The negative electricity spoken of in this last sentence, "as carried by the spray from the sea," was certainly due to the inductive effect of the ordinary electrostatic force in the air close above the water, by which every drop or splash breaking away from the surface must become negatively electrified; but this only partially explains the difference which I observed between the road station and the house station. We now know, by the second of Lenard's two discoveries to which I have alluded, that every drop of the salt-water spray, falling on the ground or rocks wetted by it, must have given positive electricity to the adjoining air. The air, thus positively electrified, was carried towards and over the house by the on-shore east wind which was blowing. Thus, while the road electrometer under the spray showed less electrostatic force than would have been found in the air over it and above the spray, the house electrometer showed greater electrostatic force, because of the positively electrified air blown over the house from the wet ground struck by the spray.

§ 11. The strong positive electricity which, as described in my

letter to Joule, I always found in Arran with east wind, seemed at first to be an attribute of wind from that quarter. But I soon found that in other localities east wind did not give any very notable augmentation, nor perhaps any augmentation at all, of the ordinary fair-weather positive electric force, and for a long time I have had the impression that what I observed in this respect, on the sea-beach of Brodick Bay, in Arran, was really due to the 12 nautical miles of sea between it and the Ayrshire coast, east-north-east of it; and now it seems to me more probable than ever that this is the explanation, when we know from Lenard that the countless breaking waves, such as even a gentle east wind produces over the sea between Ardrossan and Brodick, must every one of them give some positive electricity to the air, wherever a spherule of spray falls upon unbroken water. It becomes now a more and more interesting subject for observation (which I hope may be taken up by naturalists having the opportunity) to find whether or not the ordinary fine-weather positive electric force at the sea-coast in various localities is increased by gentle or by strong winds from the sea, whether north, south, east, or west of the land.

§ 12. From Lenard's investigation we now know that every drop of rain falling on the ground or on the sea,* and every drop of fresh-water spray of a breaking wave falling on a fresh-water lake sends negative electricity from the water surface to the air; and we know that every drop of salt water, falling on the sea from breaking waves, sends positive electricity into the air from the water surface. Lenard remarks that more than two-thirds of the earth's surface is sea, and suggests that breaking sea waves may give contributions of positive electricity to the air which may possibly preponderate over the negative electricity given to it from other sources, and may thus be the determining cause of the normal fair-weather positive of natural atmospheric electricity. It seems to me highly probable that this preponderance is real for atmospheric electricity at sea. In average weather, all the year round, sailors in very small vessels are more wet by sea-spray than by rain; and I think it is almost certain that more positive electricity is given to the air by breaking waves than negative electricity by rain. It seems also probable that the positive electricity from the waves is much more carried up by strong winds to considerable

* "Ueber die Electricität der Wasserfälle." *Annalen der Physik und Chemie*, 1892 (Vol. 46), page 631.

heights above the sea, than the negative electricity given to the air by rain falling on the sea, the greater part of which may be quickly lost into the sea, and but a small part carried up to great heights. But it seems to me almost certain that the exceedingly rapid recovery of the normal fair-weather positive, after the smaller positive or the negative atmospheric electricity of broken weather, which was first found by Beccaria in Italy, 120 years ago, and which has been amply verified in Scotland and England, could not be accounted for by positively electrified air coming from the sea. Even at Beccaria's Observatory, at Garzegna di Mondovi * in Piedmont, or at Kew, or Greenwich, or Glasgow, we should often have to wait a very long time for reinstatement of the normal positive after broken weather, if it could only come in virtue of positively electrified air blowing over the place from the sea; and several days at least would have to pass before this result could possibly be obtained in the centre of Europe.

§ 13. It has, indeed, always seemed to me probable that the rain itself is the real restorer of the normal fair-weather positive. Rain or snow, condensing out of the air high up in the clouds, must itself, I believe, become positively electrified as it grows, and must leave positive electricity in the air from which it falls. Thus, rain falling from negatively electrified air would leave it less negatively electrified, or non-electrified, or positively electrified; rain falling from non-electrified air would leave it positively electrified; and rain falling from positively electrified air would leave it with more of positive electricity than it had before it lost water from its composition. Several times within the last thirty years I have made imperfect and unsuccessful attempts to verify this hypothesis by laboratory experiments, and it still remains unproved. But I am much interested just now to find some degree of observational confirmation of it in Elster and Geitel's large and careful investigation of the electricity produced in an insulated basin by rain or snow falling into it, which they described in a communication published in the "Sitzungsberichte" of the Vienna Academy of Sciences, of May, 1890. They find generally a large electrical effect, whether positive or negative, by rain or snow falling into the basin for even so short a time as a quarter of a minute, with, however, on the whole, a preponderance of negative electrification.

* "Electrostatics and Magnetism," xvi., § 287.

§ 14. But my subject this evening is not merely natural atmospheric electricity, although this is certainly by far the most interesting to mankind of all hitherto known effects of the electrification of air. I shall conclude by telling you very briefly, and without detail, something of new experimental results regarding electrification and diselectrification of air, found within the last few months in our laboratory here by Mr. Maclean, Mr. Galt, and myself. We hope before the end of the present session of the Royal Society to be able to communicate a sufficiently full account of our work.

§ 15. Air blown from an uninsulated tube, so as to rise in bubbles through pure water in an uninsulated vessel, and carried through an insulated pipe to the electric receiving filter, of which I have already told you, gives negative electricity to the filter; while with a small quantity of salt dissolved in the water, or sea water substituted for fresh water, it gives positive electricity to the air. There can be no doubt but these results are due to the same physical cause as Lenard's negative and positive electrification of air by the impact of drops of fresh water or of salt water on a surface of water or wet solid.

§ 16. A small quantity of fresh water or salt water, shaken up vehemently with air in a corked bottle, electrifies the air—fresh water negatively, salt water positively. A "Winchester quart" bottle (of which the cubic content is about two litres and a half), with a quarter of a litre of fresh or salt water poured into it, and closed by an india-rubber cork, serves very well for the experiment. After shaking it vehemently till the whole water is filled with fine bubbles of air, we leave it till all the bubbles have risen and the liquid is at rest, then take out the cork, put in a metal or india-rubber pipe, and, by double-acting bellows, draw off the air, and send it through the electric filter. We find the electric effect, negative or positive, according as the water is fresh or salt, shown very decidedly by the quadrant electrometer, and this even if we have kept the bottle corked for two or three minutes after the liquid has come to rest before we take out the cork and draw off the air.

§ 17. An insulated spirit lamp or hydrogen lamp being connected with the positive or with the negative terminal of a little Voss electric machine, and its fumes (products of combustion mixed with

air) sent through our block-tin pipe, 4 metres long and 1 centimetre bore, ending with a short insulating tunnel of paraffin and the electric filter, gives strong positive or strong negative electricity to the filter.

§ 18. Using the little biscuit-canister and electrified needle, as described in our communication* to the Royal Society "On the Diselectrification of Air," but altered to have two insulated needles with varied distances of from half a centimetre to 2 or 3 centimetres between them, we find that when the two needles are kept at equal differences of potential positive and negative from the enclosing metal canister, little or no electrification is shown by the electric filter; and when the differences of the potential from the surrounding metal are unequal, electrification of the same sign as that of the needle, whose difference of potential is the greater, is found on the filter. When a ball and needle point are used, the effect found depends chiefly on the difference of potentials between the needle point and the surrounding canister, and is comparatively little affected by opposite electrification of the ball. When two balls are used, and sparks in abundance pass between them, but little electricity is deposited by the sparks in the air, even when one of the balls is kept at the same potential as the surrounding metal.

[The communication was illustrated by a repetition of some of the experiments shown on the occasion of a Friday evening lecture† on "Atmospheric Electricity," at the Royal Institution, London, on the 18th of May, 1860, in which one-half of the air of the lecture room was electrified positively, and the other half negatively, by two insulated spirit lamps mounted on the positive and negative conductors of an electric machine.]

* *Proc.* R.S., March 14th, 1895.

† "Electrostatics and Magnetism," xvi., §§ 285, 286.

REPORTS OF SECTIONS.

SESSION 1894-95.

[Received at Meeting of Society, 1st May, 1895.]

1. Report of the Architectural Section.

During the Session eight Meetings were held. The Opening Meeting—*Friday, 9th November*, 1894—took the form of a Conversazione, which was very successful.

Monday, 19th November, 1894.—Mr. T. L. Watson, architect, F.R.I.B.A., President of the Section, delivered his Opening Address, which was illustrated by numerous lime-light views.

Monday, 3rd December, 1894.—Mr. Thomas Gildard, architect, read a paper entitled "An Old Glasgow Architect on some Older Ones."

Monday, 17th December, 1894.—Mr. Alexander N. Paterson, M.A., read a paper on "Some Principles of Decoration." The paper was illustrated by lime-light views.

Monday, 21st January, 1895.—Mr. Francis H. Newbery, Head Master, School of Art, read a paper on "A Look into the Workshops past and present."

Monday, 4th February, 1895.—Mr. James Paton, F.L.S., Curator, Corporation Galleries, read a paper on "Mosaics," which was illustrated by lime-light views.

Monday, 18th February, 1895.—Mr. Richard Ferris, sculptor, read a paper on "The Relation of Modelling to Sculpture and the Industrial Arts." The paper was illustrated by lime-light views.

Monday, 18th March, 1895.—Mr. Lewes R. Crosskey, of the Technical College, read a paper on "Industrial Art, with special reference to the Training of Artizans."

At a Joint-Meeting of the Section and Society held on *Wednesday, 6th March*, 1895, Colonel R. W. Edis, architect, F.S.A., London, read a paper on "Internal Arrangements and Decorative Treatment of Town Houses."

The thanks of the Section are due to all those gentlemen.

During the Session twelve Associates of the Section were elected.

The Annual Meeting for the election of Office-Bearers and the transaction of general business was held in the Rooms on *Monday, 18th March*, 1895, when the gentlemen named on p. 270 were elected to office.

A. LINDSAY MILLER, Architect,
Hon. Secretary,
122 Wellington Street.

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2. REPORT OF THE GEOGRAPHICAL AND ETHNOLOGICAL SECTION.

During the Session there have been no special communications from the Section, but five Meetings have been held under the joint arrangement with the Royal Scottish Geographical Society, at which the following papers were read :—

(1.) "Andorra : the Republic of the Pyrenees," by Mr. John Smith, on 24th January, 1895;

(2.) "Reminiscences of Travel on Board a Man-of-War," by Admiral Colomb, on 11th February, 1895;

(3.) "Manchuria," by the Rev. Dr. Ross, of Mukden, on 28th February, 1895;

(4.) "British New Guinea," by Sir Wm. Macgregor, K.C.M.G., on 12th March, 1895; and

(5.) "Ice-bound on Kolquer, in Barent's Sea," by Mr. Aubyn Wevor-Battye, on 25th March, 1895.

ROBERT FULLERTON, M.D.,
Secretary.

3. Biological Section.

4. Chemical Section.

Both of these Sections are for the present suspended by vote of Council, 26th November, 1890.

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5. Report of the Economic Science Section.

A Meeting of the Section was held on 3rd October, 1894, at which the Office-Bearers for the year were elected. [Their names appear on p. 271.]

The Presidential Address by Dr. Wm. Smart, President of the Section, was delivered before a Meeting of the Society on 21st Nov., his subject being the "Municipal Industries of Glasgow."

On 19th December, 1895, Mr. Robert Peel Lamond, solicitor, Glasgow, delivered an address on "The Taxation of Land." (Read before the Society, and subsequently published in pamphlet form.)

At both of those Meetings members of the Town Council of Glasgow and the Glasgow Trades Council were present, and took part in the discussions which followed.

The papers of several gentlemen who had been prepared to deliver them had unavoidably to be held over till next session.

A motion by the President, that students attending classes of Economics in Glasgow and working-men members of trades should be entitled to attend and take part in the proceedings of Meetings of the Section, on payment of an annual subscription of one shilling, was considered at a Meeting of the Society, and subsequently withdrawn by the proposer.

Robert Lamond,
Hon. Secretary of Section.

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6. Report of the Mathematical and Physical Section.

There was no Meeting of this Section held this Session. A Meeting of Office-Bearers was called, but, as there was no quorum, no business was transacted. Papers by several of them, however, have been read at Meetings of the Society.

Magnus Maclean,
Hon. Secretary.

7. Report of the Sanitary and Social Economy Section.

A Meeting of this Section was held on 29th October, 1894, at which the Office-Bearers for the year were elected. [Their names are given on p. 270.]

The following papers were read before the Society during the course of the Winter Session:—

Professor Wright, on "The Labour Colony and its Adaptation to our Social Needs."

James R. Motion, on "Notes on the Scottish Poor Law, the Unemployed, and Labour Colonies."

G. C. Thomson, F.C.S., on "Smoke Abatement with reference to Steam-boiler Furnaces."

Professor Glaister, on "Anti-Toxin Treatment of Diphtheria."

W. R. M. Church, C.A.,
75 St. George's Place, Glasgow,
Hon. Secretary.

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8. Report of the Philological Section.

The Section has been continued without any material change in Office-Bearers or work. It has held no Special Meetings, but provided one paper for a Meeting of the Society.

James Colville, D.Sc.,
Hon. Secretary of Section.

MINUTES OF SESSION,

1894-95.

7th November, 1894.

The Philosophical Society of Glasgow held its First Meeting for Session 1894-95, in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 7th November, 1894, at Eight o'clock—Professor John Ferguson, LL.D., President, in the Chair.

1. The Minutes of Meeting held on 2nd May, 1894, were read and approved of, and signed by the Chairman.

2. The President then proceeded to deliver the Opening Address, which dealt with the results of recent inquiries regarding the early history of the Science of Chemistry. On the motion of Professor Sexton, the President was awarded a very hearty vote of thanks for his address.

3. Mr. Nicol Brown, F.G.S., London, read a paper on "The Profit and Loss of Gold Mining: Ancient and Modern." A discussion followed, in which the speakers were Mr. H. A. Jones (Cassel Company), Mr. George Ritchie, Professor Rhymer Marshall, and Professor Sexton. Mr. Brown briefly replied, and, on the motion of the President, he was awarded a very cordial vote of thanks.

4. Mr. George Harley and Mr. A. B. Dick-Cleland were appointed Auditors to examine the Treasurer's Accounts for the year 1893-94.

5. The Chairman announced that all the new Candidates for admission into the Society—as follow—had been elected:—

1. Mr. George M. Mathie, Chemist, 15 Wardlawhill Terrace, Rutherglen. Recommended by Mr. W. J. Chrystal, Mr. R. R. Tatlock, and Mr. John Tatlock.

2. Mr. Archibald Campbell, Shipowner, Springfield Quay. Recommended by Mr. William Martin, Mr. Patrick Falconer, and Mr. Archibald Watson.

3. Mr. A. M. WILLIAMS, M.A., Lecturer, E.C. Training College, 13 Annfield Terrace, W., Partick. Recommended by Prof. A. Humboldt Sexton, Mr. L. H. Cooke, and Prof. G. G. Henderson.

4. Mr. W. ACKROYD BOWER, Chemical Engineer, Govan Iron Works. Recommended by Mr. George H. Laird, Prof. Ferguson, and Mr. John Mayer.

5. Dr. JOHN MACINTYRE, 179 Bath Street. Recommended by Professor M'Kendrick, Mr. John Mann, Jun., C.A., and Dr. Freeland Fergus.

6. Mr. WILLIAM CRAWFORD MENZIES, Manager, City Improvement Trust, 34 Trongate. Recommended by Lord Provost Bell, Bailie Chisholm, and Bailie Parnie.

7. Mr. JAMES RUSSELL COMBE, Heating Engineer, 257 West Campbell Street. Recommended by Mr. John Turnbull, Jun., Mr. Gilbert Thomson, C.E., and Mr. John Mayer.

21st November, 1894.

The Annual General Meeting of the Society was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 21st November, 1894, at Eight o'clock—Professor John Ferguson, LL.D., F.R.S.E., President in the Chair.

1. The Minutes of the First Ordinary General Meeting for Session 1894-95, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 1st November, were admitted to the Membership of the Society:—

1. Mr. GEORGE M. MATHIE, Chemist, 15 Wardlawhill Terrace, Rutherglen.
2. Mr. ARCHIBALD CAMPBELL, Shipowner, Springfield Quay.
3. Mr. A. M. WILLIAMS, M.A., Lecturer, E.C. Training College, 13 Annfield Terrace, W., Partick.
4. Mr. W. ACKROYD BOWER, Chemical Engineer, Govan Iron Works.
5. Dr. JOHN MACINTYRE, 179 Bath Street.
6. Mr. WILLIAM CRAWFORD MENZIES, Manager, City Improvement Trust, 34 Trongate.
7. Mr. JAMES RUSSELL COMBE, Heating Engineer, 257 West Campbell Street.

3. The Annual Report by the Council on the State of the Society, having been printed in the Billet convening the Meeting,

was held as read. Its adoption was moved from the Chair, and unanimously agreed to. The Report was as follows :—

Report of Council for Session 1893-94.

I. *Meetings.*—Professor Ferguson, President of the Society, opened the work of Session 1893-94 by delivering an address on "The Work of the Philosophical and other Scientific Societies," on the evening of Wednesday, 1st November, 1893. Subsequently, other twelve meetings were held during the session, which terminated on 2nd May, 1894. Including the Opening Address, twenty-two communications were made to the Society's meetings, in addition to which there were held, in the course of the session, four meetings, under the joint-arrangement with the Royal Scottish Geographical Society, at which four papers were read on geographical subjects.

II. *Membership.*—At the beginning of the Session there were 640 Ordinary Members on the Roll. In course of the Session, 31 candidates were elected (two of whom, however, have not yet completed their Membership by payment of entry-money), making 671. Of these, 30 have resigned, 8 have died, 1 has left Glasgow, and the name has been placed on the "Suspense List," and 3 have been struck off the Roll for non-payment of subscriptions, so that at the beginning of 1893-94 there were 629 Members, being an increase of 11. Of the new Members admitted during the Session, 3 qualified themselves as Life Members. There are now 131 Members of that class. In the List of Honorary Members, the number of whom is limited to 20, there are five vacancies, so that the Roll now includes 15 Honorary Members, 4 being Continental, 4 American or Colonial, and 7 British. The number of Corresponding Members remains at 10, as it was last year. The Membership of the Society, then, is as follows :—Honorary Members, 15; Corresponding Members, 10; Ordinary Members (Annual and Life), 629; or a total of 654.

III.—*Deceased Members.*—With the exception of Mr. James Reid, Lord Dean of Guild, no Ordinary Members of marked prominence were removed from the roll by death during the session. That gentleman joined the Society in the year 1870, and remained in the membership till his lamented death in June of this year. He had attained an eminent position, both in the locomotive-engine industry and as a citizen of Glasgow. Mr. Reid never took any prominent part in the work of the Society, but for a number of years he frequently attended its meetings. The Society's list of Honorary Members has been made much the poorer by the death of Professor John Tyndall, D.C.L., F.R.S., &c., who held an honoured position on that list from the year 1880 till his death in December, 1893.

IV. *Sections.*—*The Architectural Section,* which has now been a prominent and active portion of the Society for the long period of twenty-five years, had a very successful session, which embraced eight meetings, and terminated on 19th March. The Opening Address of the President (Mr. Campbell Douglas) was accepted by the Council for publication in the Society's *Proceedings.* Other two papers read before the Section were

offered and accepted for publication. The *Economic Science Section* held three separate meetings in the course of the session, and supplied three important communications for the *Proceedings*, two of them being read before ordinary meetings of the Society. None of the other Sections held any separate meetings for the reading of papers.

V. *Proceedings, Volume XXV.*—This Volume contains seventeen communications, six of which are illustrated by plates—sixteen in number,—and by several small figures which are embodied in the text.

VI. *Finance.*—The Treasurer's Statement opens with a balance of £271 12s. 6½d. An effort was made to apply this fund to reduce the Bond over the property—with an equal sum from the Institution of Engineers and Shipbuilders, the Co-proprietors,—but this being found impracticable at the time, an Investment was made in December, 1893, by the purchase of £360 Caledonian Railway 3 per cent. Preferred Converted Stock, costing £294 18s. 3d. The Accounts close with a balance in Treasurer's hands of £2 17s. 6½d., so that there has been an increase of funds during the year of £26 3s. 3d. All current indebtedness of the Society up to the closing date of session has been paid.

By order and on behalf of the Council.

(Signed) JOHN MAYER,
Secretary.

4. The Treasurer's audited Statement of the Funds of the Society, which had also been printed in the Billet, was next submitted by the Chairman, and its adoption was unanimously approved of. The Abstract of Treasurer's Account of the Graham Medal and Lecture Fund, and that of the Science Lectures Association Fund, were also submitted and approved of. These Statements, signed by the Auditors, were laid on the table. They are subjoined.

5. Mr. John Robertson, on behalf of the Library Committee, submitted the Report on the State of the Library. Its adoption was agreed to, and, on the motion of Mr. Robertson, the thanks of the Society were awarded to the donors of Books to the Library during the year. The following is the Report:—

Report of the Library Committee.

Your Committee have pleasure in reporting that the number who read from the Library, and especially those who use it for consultation, still continues to increase.

During the past year 734 volumes were issued to 527 members, in addition to a very much larger number of consultations.

Dr. ABSTRACT OF HONORARY TREASURER'S
AND COMPARISON WITH

			1893-94.	*1892-93.*
To Balance in Bank, less due Treasurer, from last year, .			£271 12 6½	*£250 7 7½*
,, Subscriptions to 31st October, 1894—				
29 Entry-moneys of 1893-94 at 21s., .		£30 9 0		*45 3 0*
Annual Dues at 21s.—				
Arrears, 1891-92, ...	£4 4 0			
,, 1892-93, ...	9 9 0			
For 1893-94, 447 Ordinary Members, ...	469 7 0			
,, ,, 26 New Members,	27 6 0			
		510 6 0		*519 15 0*
Life Subscriptions at £10 10s.—				
1 Old Member, ...	£10 10 0			
3 New Members, ...	31 10 0			
		42 0 0		*94 10 0*
			582 15 0	
,, Dividends on Investment—				
Caledonian Railway, April, 1894, less tax,		£5 4 10		
,, ,, Oct., ,, ,,		5 4 7		
			10 9 5	*0 0 0*
,, General Receipts—				
Bank Interest, ...		£2 7 1		*3 0 2*
Proceedings and Catalogues sold, ...		0 17 0		*0 8 10½*
			3 4 1	
,, Legacy by the late Sir Michael Connal— First instalment, less duty, ...			2 5 0	*0 0 0*
,, Architectural Section—				
90 Associates' fees for 1893-94, at 5s., ...			22 10 0	*15 10 0*
,, Economic Science Section—				
16 Associates' fees for 1893-94, at 5s., ...			4 0 0	*7 0 0*
,, Geographical and Ethnological Section—				
Associates' fees, ...			0 0 0	*8 5 0*
			£896 16 0½	*£948 19 8*

Memo. by Treasurer.—The Society's Investments are—(1) Bath Street Joint Buildings, as in last Account, ... £3,547 8 1¼
whereof, Paid from Society's Funds, ... £2,047 8 1½
Do. Society's half of £3,000 Bond, . 1,500 0 0
(2) Caledonian Railway Stock, as in foregoing Account, . . 294 18 3

£3,842 6 4¼

J. M.

ACCOUNT—SESSION 1893-94, **Cr.**

SESSION 1892-93.

		1893-94.	1892-93.
By GENERAL EXPENDITURE to 31st October, 1894—			
Salary to Secretary,	£75 0 0		*£75 0 0*
Allowance for Treasurer's Clerks,	15 0 0		*15 0 0*
		£90 0 0	
New Books & Periodicals, British & Foreign,	£111 12 6½		*145 15 3½*
Bookbinding,	15 15 2		*44 11 9*
Printing Circulars, *Proceedings*, &c.,	148 12 0		*158 0 0*
Lithographs, &c., for *Proceedings*, &c.,	19 5 0		*15 15 6*
Postage and delivery of Circulars, Letters, &c.,	35 15 10		*34 18 5*
Stationery, &c.,	3 11 11		*12 1 3*
		334 12 5½	
Fire Insurance on Library for £5,400,	£6 1 3		*6 1 3*
Postages, &c., per Secretary, £2 2s. 6d.; per Treasurer, £2 9s. 6d., & Sundries, 5s. 10d.,	4 17 10		*6 7 7½*
		10 19 1	
,, Joint Expenses of Rooms—Society's half of £327 7s. 2d., being Interest on Bond, Insurance, Taxes, Cleaning, Repairs, Lighting, and Heating; Salaries of Curator and Assistant, less half of £54 12s. 6d., Revenue from Letting,		136 7 4	*132 19 0*
,, LECTURE EXPENSES—			
Scottish Geographical Society, Rent for four Joint Lectures,	£4 5 0		*4 10 0*
Use of Lantern, £1 0s. 8d.; Sundries, 6s. 6d.,	1 7 2		*5 8 6*
		5 12 2	
,, SUBSCRIPTIONS TO SOCIETIES—			
Ray Society, 1893,	£1 1 0		
Palæontographical Society, 1893,	1 1 0		
		2 2 0	*2 2 0*
,, ARCHITECTURAL SECTION—			
Expenses per Treasurer of Section,		13 16 9	*11 7 6*
,, ECONOMIC SCIENCE SECTION—			
Expenses per Treasurer and Secretary of Section,	3 10 5½		
Printing Account,	2 0 0		
		5 10 5½	*0 19 9½*
,, GEOGRAPHICAL AND ETHNOLOGICAL SECTION—			
Expenses per Treasurer of Section,		0 0 0	*6 6 9*
,, SANITARY AND SOCIAL ECONOMY SECTION—			
Expenses per Treasurer of Section,		0 0 0	*0 2 6*
,, INVESTMENT—			
Caledonian Railway £360 3 per cent. Preferred Converted, and Expenses,		294 18 3	*0 0 0*
,, BALANCES, viz.:—			
In Clydesdale Bank,		0 0 0	*271 12 6½*
In Treasurer's hands,		2 17 6½	*0 0 0*
		£896 16 0½	*£948 19 8*

GLASGOW, *14th November, 1894.*—We, the Auditors appointed by the Society to examine the Treasurer's Accounts for the year 1893-94, have examined the same, of which the above is an Abstract, and have found them correct, the Balance in Treasurer's hands being Two Pounds Seventeen Shillings and Sixpence-halfpenny.

(Signed) GEORGE HARLEY.

JNO. MANN, C.A., *Honorary Treasurer.* A. B. DICK-CLELAND.

GRAHAM MEDAL AND LECTURE FUND.

Dr. ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1893-94. Cr.

CAPITAL AT 1ST NOVEMBER, 1893—		
Glasgow and South-Western Railway Co. 4 % Preference Stock in name of the Philosophical Society, in Trust,	£250 0 0	
Value of Die at H.M. Mint,	18 18 0	
		£268 18 0
Cash in Bank,		33 18 5
REVENUE—		
Dividend, April, 1894, less Tax,	£4 17 1	
„ Oct. „ „	4 16 10	
Interest from Bank,	0 10 3	
		10 4 2
		£313 0 7

CAPITAL AT 31ST OCTOBER, 1894—		
Investment, *per contra*,	£250 0 0	
Die,	18 18 0	
		£268 18 0
BALANCE, BEING REVENUE—		
In Bank, on Deposit Receipts,		44 2 7
		£313 0 7

GLASGOW, 14th November, 1894.—Examined and found correct.

(Signed) GEORGE HARLEY.
A. B. DICK-CLELAND.

JNO. MANN, C.A., *Treasurer.*

THE SCIENCE LECTURES ASSOCIATION FUND.

Dr. ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1893-94. Cr.

Dr.

CAPITAL AT 1ST NOVEMBER, 1893—		
£200 Caledonian Railway Company 4% Preference Stock, No. 1, in name of the Philosophical Society, in Trust, cost - - - - - - - -	£244 4 8	
On Deposit Receipt, - - - - -	8 5 4	
		£252 10 0
Cash in Bank (Revenue), - - - - - -		32 17 4
REVENUE—		
Dividend, April, 1894, less Tax, - -	£3 17 8	
,, Oct., ,, ,, - -	3 17 5	
Premium on Allotment, - - -	0 6 9	
Interest from Bank, - - - - -	0 11 11	
		8 13 9
		£294 1 1

Cr.

CAPITAL AT 31ST OCTOBER, 1894—		
Investment, *per contra*, - -	£244 4 8	
In Bank on Deposit Receipt, -	8 5 4	
		£252 10 0
BALANCE, BEING REVENUE—		
In Bank, on Deposit Receipts, - - - - -		41 11 1
		£294 1 1

GLASGOW, 14th November, 1894.—Examined and found correct.

(Signed) GEORGE HARLEY.
A. B. DICK-CLELAND.

JNO. MANN, C.A., *Treasurer*.

Two additional Societies were added to the list of exchanges—the Highland and Agricultural Society of Scotland and the Texas Academy of Sciences. These make a total of 170 Societies, from which we received during the year 108 volumes and 104 parts of works.

The Society, on the recommendation of the Committee, added 63 volumes and 27 parts of works by purchase, while 15 volumes, 10 parts of works, and 9 pamphlets were presented.

Of the periodicals at present received at the Library, 69 are bought and 31 presented. These form altogether 102 volumes a year.

The number of volumes bound during the session was 184.

In Volume XXV. of the *Proceedings*, pp. 263-275, there will be found a list of the additions to the Library by purchase, up to June, 1894; the titles of the books presented, with the names of the donors, the names of the societies and public departments with which exchanges are effected, and a list of the periodicals received at the Library.

The Committee are desirous of meeting the wants of the members in the purchase of books, and will be glad to have recommendations placed in the book kept in the Library for that purpose.

The Library is particularly rich in works, both for reading and for reference, in all branches of science, and the Abridgements of Specifications of Patents for Inventions, and the Maps (1-inch and 6-inch) of the Geological Survey of Scotland, are at all times accessible to the members.

JOHN ROBERTSON, Librarian,
Convener.

6. The Society then proceeded to the election of Office-Bearers:—

(1) On the recommendation of the Council, and on the motion of the President, Dr. Eben. Duncan was elected to succeed Dr. Charles Gairdner, the retiring Vice-President.

(2) On the motion of the Chairman, Messrs. Mann, Robertson, and Mayer were re-elected Treasurer, Librarian, and Secretary, respectively.

(3) On the motion of Dr. G. A. Turner the following gentlemen were elected members of Council:—Dr. John Glaister; Professor A. H. Sexton, F.C.S., &c.; Mr. A. Lindsay Miller, Architect; and Mr. Alexander Scott, in succession to Mr. Magnus Maclean, Dr. Eben. Duncan, Dr. G. A. Turner, and Mr. William Jolly.

(4) On the motion of Mr. Alexander Scott, and on behalf of the Council of the Section, Dr. George A. Turner was elected President of the Geographical and Ethnological Section in room of Sir Renny Watson, and Dr. Robert Fullerton was elected Secretary and Treasurer in succession to Dr. Turner. The Council was reconstituted by the election of Dr. Colville for the term of three years. The Councils of the other Sections were also reconstituted, in accordance with Resolutions of Society of 18th November, 1885, and 2nd February, 1887. (The Lists of the Office-Bearers of the Society and of the various Sections are given on pp. 268-271.)

7. On the motion of the President, the thanks of the Society were awarded to the retiring Vice-President and Members of Council.

8. Dr. William Smart and Mr. George Barclay, on behalf of the Economic Science Section, moved and seconded the following resolution :— "That Students attending Classes on Political Economy and Working Members of Trades be admitted Associates of the Economic Science Section on payment of the Annual Subscription of One Shilling." Some discussion took place on the subject of the motion, and it was eventually agreed to remit the matter in the first place to the Council for a deliverance upon it.

9. Dr. William Smart, M.A., President of the Economic Science Section, then read a paper on "The Municipal Industries of Glasgow." A discussion arose upon it, in which the speakers were Dr. Dyer, Mr. Jas. Chalmers, Dr. Glaister, Mr. Mayer, Mr. Francis Smith, and Mr. Osborne. A very hearty vote of thanks was passed to Dr. Smart, on the motion of the Chairman.

10. The Chairman announced that all the new Candidates for admission into the Society, as under, had been elected :—

1. Dr. Alex. Muir Smith, 59 Sardinia Terrace, Hillhead. Recommended by Mr. Magnus Maclean, Dr. J. G. M'Kendrick, and Prof. Ferguson.
2. Prof. Henry Jones, The University, Glasgow. Recommended by Mr. Walter W. Blackie, Prof. Ferguson, and Mr. William Lang.
3. Mr. John Inglis, Pointhouse Shipyard. Recommended by Lord Kelvin and Professors Barr and Biles.
4. Mr. John Forbes Ferguson, Writer, 138 West George Street. Recommended by Mr. D. Gardner, Mr. A. M. Lindsay, and Mr. John Mayer.
5. Mr. George T. Beilby, F.I.C., Chemical Engineer, St. Kitts, Slateford. Recommended by Dr. John Clark, Prof. G. G. Henderson, and Mr. Chas. A. Fawsitt.
6. Professor L. Becker, Ph.D., F.R.A.S., The Observatory, Glasgow. Recommended by Prof. Ferguson, Dr. G. A. Turner, and Mr. Magnus Maclean.

5th December, 1894.

The Second Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 5th December, 1894, at Eight o'clock—Professor John Ferguson, LL.D., F.R.S.E., President, in the Chair.

1. The Minutes of the Annual General Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 19th November, were admitted to the Membership of the Society:—

1. Dr. Alex. Muir Smith, 50 Sardinia Terrace, Hillhead.
2. Prof. Henry Jones, The University, Glasgow.
3. Mr. John Inglis, Pointhouse Shipyard.
4. Mr. John Forbes Ferguson, Writer, 138 West George Street.
5. Mr. George T. Beilby, F.I.C., Chemical Engineer, St. Kitts, Slateford.
6. Professor L. Becker, The Observatory, Glasgow.

3. Mr. Magnus Maclean, M.A., F.R.S.E., read a paper on "Progress in the Development of Flying Machines," which was illustrated by numerous lantern slides. Some remarks were made on the subject of the paper by the Chairman, Prof. Blyth, and Mr. Sam Mavor. Mr. Maclean briefly replied, and was awarded the best thanks of the Society for his communication.

4. Prof. Blyth made a short communication to the Society on "Experiments with Loose Electrical Contacts," which was experimentally illustrated. A vote of thanks was passed to Prof. Blyth for his communication.

5. In the absence of Dr. William Smart, and on behalf of the Economic Science Section, the Chairman submitted the following motion, which had received the approval of the Council, andof which notice was given at last meeting of the Society:—"That Students attending Classes on Political Economy and Working Members of Trades be admitted to meetings of the Economic Science Section, with the right to take part in the discussion of papers read at them, on payment of an *Annual Subscription of One Shilling.*" Mr. Barrett seconded the motion. Mr. J. C. Arnot and Dr. Freeland Fergus moved and seconded an amendment to the effect that no such privilege be granted on the terms specified. No vote was taken, as it was thought proper to postpone further consideration of the subject until next meeting for the attendance of Dr. Smart.

6. The Chairman announced that both Candidates named in the Ballot Papers had been elected members of the Society, namely:—

1. Mr. Richard Brown, Writer, 138 West George Street. Recommended by Mr. James Campbell of Tullichewan, Mr. John T. Costigane, and Mr. William Costigane.
2. Mr. George Scott Hendry, Plumber and Heating Engineer, 87 Bothwell Street. Recommended by Mr. A. Malloch Bayne, Mr. T. L. Watson, and Mr. A. Lindsay Miller.

19th December, 1894.

The Third Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 19th December, 1894, at 7.45 o'clock—Professor John Ferguson, LL.D., F.R.S.E., President, in the Chair.

1. The Minutes of the Second Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 5th December, were admitted to the Membership of the Society:—

1. Mr. Richard Brown, Writer, 138 West George Street.
2. Mr. George Scott Hendry, Plumber and Heating Engineer, 87 Bothwell Street.

3. Mr. R. P. Lamond, Writer, read a paper on "The Taxation of Land" (a Communication from the Economic Science Section). A discussion ensued, in which the speakers were Dr. Smart, Mr. Cree, Councillor M'Lardy (a visitor), Mr. King, and Mr. James Chalmers. On the motion of the Chairman, a vote of thanks was passed to Mr. Lamond, who replied at some length to the criticisms made on his paper.

4. Professor Wright's paper, which was announced in the Billet, was postponed till next meeting of the Society.

5. The motion from the Economic Science Section was formally submitted by Dr. Smart and seconded by Mr. Barrett. At the request of Mr. Arnot, the Council Minute bearing on the question was read by the Secretary. Mr. Arnot again submitted his amendment, which was seconded by Dr. Freeland Fergus.

Remarks on the question at issue were then made by Mr. Jas. Chalmers, Dr. Turner, Dr. E. Duncan, Prof. Sexton, Mr. A. Scott, and Prof. Jamieson. A vote was taken, but as there was some doubt as to the numbers voting, which could not then be settled, as some members had left the meeting, it was agreed to adjourn the matter till meeting of 9th January, 1895. (The Secretary has since been informed by Dr. Smart that, with the consent of his seconder, Mr. Barrett, he desires to withdraw the motion.)

6. The Chairman announced that the Candidate balloted for, Mr. J. J. Spencer, Merchant, Edgehill, Kelvinside, recommended by Dr. Smart, Prof. Ferguson, and Mr. Mayer, had been unanimously elected.

9th January, 1895.

The Fourth Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 9th January, 1895, at Eight o'clock—Professor John Ferguson, LL.D., F.R.S.E., President, in the Chair.

1. The Minutes of the Third Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. J. J. Spencer, Merchant, Edgehill, Kelvinside, elected on 19th December, 1894, was admitted to the Membership of the Society.

3. Professor A. H. Sexton, F.I.C., M.I.M. & M., Glasgow and West of Scotland Technical College, read a paper on "Aluminium: Is it to be the Metal of the Future?" which was very fully illustrated by specimens. A discussion ensued, in which the speakers were the President, Professor Marshall, Mr. William Lang, Mr. G. C. Thomson, Mr. Gilbert Thomson, and Mr. H. Brier. A very cordial vote of thanks was passed to the author of the paper.

4. Professor R. P. Wright, Glasgow and West of Scotland Technical College, read a paper on "The Labour Colony System, and its Adaptation to our Social Needs," for which he received

the thanks of the Society. The discussion upon the paper was postponed till meeting of 6th February, when a paper on a cognate subject will be taken.

5. The Chairman announced that the following candidates had been elected to the Membership of the Society :—

1. Mr. W. H. ADDISON, Superintendent, Deaf and Dumb Institution. Recommended by Mr. Robert Gow, Dr. Eben. Duncan, and Mr. John Mann.
2. Mr. JOSHUA FERGUSON, M.A., Enfield House, Crosshill. Recommended by Dr. M'Kendrick, Professor Blyth, and Dr. Freeland Fergus.
3. Mr. JOHN KING, Ironfounder, Tigh Ruadh, Possilpark. Recommended by ex-Bailies Crawford, Wallace, and Graham.
4. Mr. JOHN WIELD, Electrical Engineer, 9 Barns Street, Ayr. Recommended by Mr. David Reid, Mr. William Adam, M.A., and Mr. John Mayer.

23rd January, 1895.

The Fifth Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 23rd January, 1895, at Eight o'clock—Professor John Ferguson, LL.D., F.R.S.E., President, in the Chair.

1. The Minutes of the Fourth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 9th January, 1895, were admitted to the Membership of the Society :—

1. Mr. W. H. ADDISON, Superintendent, Deaf and Dumb Institution, Langside.
2. Mr. JOSHUA FERGUSON, M.A., Enfield House, Crosshill.
3. Mr. JOHN KING, Ironfounder, Tigh Ruadh, Possilpark.
4. Mr. JOHN WIELD, Electrical Engineer, 9 Barns Street, Ayr.

3. Professor T. Rhymer Marshall, St. Mungo's College, read a paper on "A Visit to the Hot Lakes of New Zealand," which was illustrated by a large number of lime-light lantern views and by a large working model demonstrating how a Geyser acts. After some remarks by the President on the subject of the paper, a cordial vote of thanks was passed to Professor Marshall.

4. Mr. Howard Swan, Director of the Central School of Foreign Languages, London, read a paper on "The 'Gouin' System of Teaching Languages on the Series Method" (a Communication from the Philological Section). Dr. Colville made some remarks on the subject, and, on his motion, a vote of thanks was passed to Mr. Swan.

5. The Chairman announced that the following Candidate had been elected to the Membership of the Society:—

Mr. ROBERT PATRICK WRIGHT, Professor of Agriculture, Glasgow and West of Scotland Technical College. Recommended by Professor Ferguson, Mr. William Martin, and Mr. James Chalmers.

6th February, 1895.

The Sixth Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 6th February, 1895, at Eight o'clock—Professor John Ferguson, LL.D., F.R.S E., President, in the Chair.

1. The Minutes of the Fifth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentleman, elected on 23rd January, 1895, was admitted to the Membership of the Society:—

Professor R. PATRICK WRIGHT, Agricultural Department, Glasgow and West of Scotland Technical College.

3. Mr. George C. Thomson, F.C.S., Engineer to the late Smoke Abatement Association of Glasgow, read a paper on "Smoke Abatement with reference to Steam-boiler Furnaces" (a Communication from the Sanitary and Social Economy Section). Remarks were made on the subject of the paper by the President, Mr. H. A. Mavor, Mr. James Chalmers, and Mr. Alexander G. Moore. Mr. Thomson was cordially thanked for his paper.

4. At this stage, on the motion of the President, the chair was taken by Mr. James Chalmers in his capacity of President of the Sanitary and Social Economy Section; and Mr. James R. Motion, Acting Inspector, Barony Parochial Board, read a paper on "The Scottish Poor-Law, the Unemployed, and Labour

Colonies." A discussion was taken on it and Professor Wright's paper, the speakers being Dr. Smart, Mr. Andrew Wallace (Govan Combination), Mr. William Martin, Dr. Carswell, and the Chairman. Mr. Motion received the thanks of the Society for his valuable paper, and both he and Professor Wright briefly replied.

5. The Chairman announced that the following Candidates had been unanimously elected Members of the Society:—

1. Mr. WALTER G. CRUM, Thornliebank. Recommended by Lord Kelvin, Professor Ferguson, and William E. Kay.
2. Mr. D. S. MACNAIR, Ph.D., D.Sc., Inspector, Science and Art Department, 2 Grosvenor Terrace, Glasgow. Recommended by Mr. John G. Kerr, M.A., Professor G. G. Henderson, M.A., D.Sc., and Mr. William E. Kay.

20th February, 1895.

The Seventh Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 20th February, 1895, at Eight o'clock—Mr. F. T. Barrett, Member of Council, in the Chair.

1. The Minutes of the Sixth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 6th February, 1895 were admitted to the Membership of the Society:—

1. Mr. WALTER G. CRUM, Thornliebank.
2. Mr. D. S. MACNAIR, Ph.D., B.Sc., Inspector, Science and Art Department, 2 Grosvener Terrace, Glasgow.

3. A paper by Mr. James Hendrick, B.Sc., F.I.C., Agricultural Department, Glasgow and West of Scotland Technical College, late of the Agricultural College, Cirencester, entitled "Education and Agriculture: A Discussion of the Bearings of the Technical Education Movement on our Greatest Industry," was read by Professor R. P. Wright for the author, who was absent through indisposition. Some remarks were made on the subject of the paper by Dr. Henry Dyer and by

Mr. Gilchrist (a visitor), who had been a member of an Agricultural Deputation from Scotland to the United States. At the close of the discussion a very hearty vote of thanks was passed to Mr. Hendrick, and to Professor Wright for reading the paper.

The Chairman announced that Mr. William Borland, Writer, 142 St. Vincent Street, recommended by Dr. J. B. Russell, Mr. James D. Borthwick, and Mr. F. T. Barrett, had been unanimously elected a Member of the Society.

6th March, 1895.

The Eighth Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 (conjointly with the Architectural Section) was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 6th March, 1895, at Eight o'clock—Mr. William Lang, F.C.S., Vice-President, in the Chair.

1. The Minutes of the Seventh Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. William Borland, Writer, 142 St. Vincent Street, elected on 20th February, 1895, was admitted to the Membership of the Society.

3. At this stage Mr. Lang resigned the Chair in favour of Mr. T. L. Watson, President of the Architectural Section.

4. Colonel Robert W. Edis, Architect, F.S.A., F.R.I.B.A., of London, read a paper on "Internal Arrangement and Decorative Treatment of Town Houses." An interesting discussion followed, in which the speakers were Mr. Campbell Douglas, Mr. W. F. Salmon, Mr. P. Macgregor Chalmers, Dr. Eben. Duncan, Mr. David Thomson, Mr. Stephen Adam, Mr. John James Burnet, and the Chairman. A very cordial vote of thanks was passed to Colonel Edis for his suggestive paper, and that gentleman briefly replied.

5. The Chairman announced that the following gentlemen had been unanimously elected Members of the Society:—

1. Mr. William John Hassard, Optician, 209 Sauchiehall Street. Recommended by Dr. Thomas Reid, Dr. John Macintyre, F.R.S.E., and Dr. Freeland Fergus.

2. Mr. Hugh Duncan, M.A., LL.B., Writer, 175 West George Street. Recommended, by Professor R. Patrick Wright, Mr. F. T. Barrett, and Mr. Gilbert Thomson, C.E.

3. Mr. John Wilson, C.E., 154 West George Street (late of Dumbarton and Peru). Recommended by Mr. J. C. Rogers, Mr. Andrew Stewart, and Mr. W. S. Brown.

20th March, 1895.

The Ninth Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 20th March, 1895, at Eight o'clock—Professor John Ferguson, LL.D., President, in the Chair.

1. The Minutes of the Eighth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 6th March, 1895, were admitted to the Membership of the Society:—

1. Mr. William John Hassard, Optician, 209 Sauchiehall Street.
2. Mr. Hugh Duncan, M.A., LL.B., Writer, 175 West George Street.
3. Mr. John Wilson, C.E., 154 West George Street.

3. Dr. John Glaister, D.P.H.(Camb.), &c., Professor of Forensic Medicine and Public Health, St. Mungo's College, read a paper on "The Anti-Toxin Treatment of Diphtheria," which was extensively illustrated on the screen by bacteriological slides. In the discussion which followed, the speakers were Mr. James Chalmers, Mr. Knight, and Dr. Snodgrass. Dr. Glaister was very cordially thanked for his paper.

27th March, 1895.

An Extra Meeting of the Society was held in the Natural Philosophy Class-Room at the University, on the Evening of Wednesday, 27th March, 1895, at Eight o'clock—Mr. William Lang, F.C.S., Vice-President, in the Chair.

Lord Kelvin, President, Royal Society, made two verbal communications to the Society—(1) "On Electrification of Air"; (2) "On Thermal Conductivity of Rocks." At the close, on the motion of Mr. H. A. Mavor, a very hearty vote of thanks was passed to his lordship. The vote was suitably acknowledged.

3rd April, 1895.

The Tenth Ordinary Meeting of the Philosphical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 3rd April, 1895, at Eight o'clock—Mr. William Lang, F.C.S., Vice-President, in the Chair.

1. The Minutes of the Ninth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Dr. Freeland Fergus read a paper on "The New Rules by the Board of Trade as to Colour Testing for Mariners and Railway Servants." A discussion ensued, in which the speakers were Mr. Magnus Maclean, Dr. Dalziel, Mr. George Henry (artist), Dr. John Fergus, Mr. Sam Mavor, Mr. Liddell (N. B. engine-driver), and Mr. Alexander Scott. Dr. Fergus replied, and was awarded a hearty vote of thanks for his interesting paper.

17th April, 1895.

The Eleventh Ordinary Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 17th April, 1895, at Eight o'clock—Mr. William Lang, F.C.S., Vice-President, in the Chair.

1. The Minutes of the Tenth Ordinary Meeting of the Society, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. Walter W. Blaikie, Edinburgh, exhibited and described his "Cosmosphere," an instrument for demonstrating many phenomena connected with Astronomical Geography and Navigation. A discussion followed, the speakers being Mr. H. A. Mavor, Mr. J. Orr (a visitor), and Dr. G. A. Turner, on whose motion a very cordial vote of thanks was passed to Mr. Blaikie.

3. The Chairman announced that the following candidate had been elected a Member of the Society:—

Mr. ARTHUR J. DAVEY, London Road Iron Works. Recommended by Lord Kelvin, Mr. Walter G. Crum, and Mr. William E. Kay.

1st May, 1895.

The Twelfth Ordinary and Closing Meeting of the Philosophical Society of Glasgow for Session 1894-95 was held in the Rooms of the Society, 207 Bath Street, on 1st May, 1895, at 8 p.m.—Professor Ferguson, LL.D., President, in the Chair.

1. The Minutes of Meeting of 17th April, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. Arthur J. Davey, London Road Iron Works, elected on 17th April, was admitted to the Membership of the Society.

3. Mr. T. L. Patterson, F.I.C., F.C.S., Greenock, read a paper on "Sugar Manufacture in Australia," by Mr. Thomas Steel, F.C.S., Sydney. It was extensively illustrated by lime-light views. A short discussion ensued, in which the speakers were Mr. Alexander Hamilton, Sugar Broker, and Mr. W. J. Mirrlees. Votes of thanks were awarded to Messrs. Steel and Patterson.

4. Mr. Robert Strathern, Civil and Mining Engineer, Glasgow, exhibited, and made some remarks on, a large mass of Native Copper found in the Serpentine Rocks near Florence, about 1,200 feet above the sea level. Some remarks were made on the subject by the President, and, on his motion, a vote of thanks was passed to Mr. Strathern.

5. Professor Ferguson, LL.D., President, continued his contributions to the History of Chemistry in France in the seventeenth century—No. II., "William Davieson, First Professor of Chemistry in the Jardin des Plantes"—for which he was awarded the thanks of the Society.

6. The Reports by Secretaries of Sections for Session 1894-95 were then submitted by the Secretary of the Society, and ordered to be printed in next volume of the *Proceedings.*

7. The President then brought the session to a close.

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The Pamunky Indians of Virginia. By John Garland Pollard. 8vo Pamphlet. 1894. From Smithsonian Institution.

The Maya Year. By Cyrus Thomas. 8vo Pamphlet. 1894. From Smithsonian Institution.

Bibliography of the Wakashan Languages. By J. C. Pilling. 8vo Pamphlet. 1894. From Smithsonian Institution.

Report of the Proceedings of the Flameless Explosives Committee. Part 1, Air and Combustible Gases. By A. C. Kayll, 1894. From North of England Institute of Mining Engineers.

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Darwin's (Dr. Erasmus) Botanic Garden. 4th Edition. 2 vols. 8vo. London, 1799. From Mr. W. Lang.

Monism as a Connecting Religion and Science. By Ernst Haeckel. 8vo. London, 1894. From the Author.

Report of Kelvingrove Museum and Corporation Galleries of Art, Glasgow, 1894. From the Superintendent.

Report of the Glasgow and West of Scotland Smoke Abatement Association, 1893. From Mr. G. C. Thomson.

Report of the British Association for 1894. (Oxford Meeting.) From the Association.

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Journal of the West of Scotland Iron and Steel Institute. Vol. 1. 1892-94. From the Institute.

Physics and Chemistry of the Voyage of H.M.S. Challenger. Part 8. Report on Oceanic Circulation. By Alexander Buchan, 1895. From the Author.

Synopsis of the Air-Breathing Animals of the Palæozoic in Canada up to 1894. By Sir William Dawson. 4to Pamphlet. From the Author.

Index of the Journal of the Society of Arts. Vols. 31-40. 1882-92. From the Society.

Bibliography of Aceto Acetic Ester and its derivatives. By P. H. Seymour From Smithsonian Institution.

Varieties of the Human Species: Principles and Methods of Classification. By G. Sergi. From Smithsonian Institution.

Smithsonian Geographical Tables. By R. S. Woodward. From Smithsonian Institution.

List of the Publications of the Bureau of Ethnology, with Index to Authors and Subjects. By F. W. Hodge. 8vo Pamphlet. 1894. From Smithsonian Institution.

An Ancient Quarry in Indian Territory. By W. H. Holmes. 8vo Pamphlet. 1894. From Smithsonian Institution.

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,, Magnetical and Meteorological Observations. 1892.

,, Spectroscopic and Photographic Results. 1892.

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,, Meridian Observations. 1885-87. From the Astronomer Royal.

Chinook Texts. By Franz Boas. From Bureau of American Ethnology.

The Siouan Tribes of the East. By James Mooney. From Bureau of American Ethnology.

Archæologic Investigations in James and Potomac Valleys. By Gerard Fowke. From Bureau of American Ethnology.

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On the Work of the Philosophical and other Scientific Societies. Presidential Address to the Philosophical Society of Glasgow. 1893. By John Ferguson. From the Author.

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Lubbock, Sir John. Ants, Bees, and Wasps. 13th Edition. 8vo. London, 1893.

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Memoir of Sir Andrew Crombie Ramsay. By Sir Archd. Geikie. 8vo. London, 1895.

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United States Geological Survey.
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(Those received in exchange are indicated by an asterisk.)

WEEKLY.

Academy.
Architect.
Athenæum.
British Architect.
British Journal of Photography.
Builder.
Building News.
Chemical News.
Comptes Rendus.
*Dingler's Polytechnisches Journal.
Economist.
Electrical Review.
Electrician.
Engineer.
*Engineering.
English Mechanic.
*Industries and Iron.
*Journal of the Society of Arts.
Journal of Gas Lighting, &c.
*Lancet.
Nature.
Notes and Queries.
*Pharmaceutical Journal.
Publishers' Circular.
Scientific American and Supplement.

FORTNIGHTLY.

Annalen der Chemie (Liebig's).
*Berichte der Deutschen Chemischen Gesellschaft.
Journal für Praktische Chemie (Erdmann's).
Zeitschrift für Angewandte Chemie.

MONTHLY.

*American Chemical Journal.
American Journal of Science.
Analyst.
Annalen der Physik und Chemie.
Annales de Chimie et de Physique.
Annales de l'Institut Pasteur.
Annales des Ponts et des Chaussées.
Annales des Sciences Naturelles. Botanique.
Annales des Sciences Naturelles. Zoologie.
Annals and Magazine of Natural History.
Antiquary.
Beiblätter zu den Annalen der Physik und Chemie.
Bookseller.
Bulletin de la Société Chimique de Paris.

Bulletin de la Société d'Encouragement.
Bulletin de la Société Géologique de France.
Bulletin de la Société Industrielle de Mulhouse.
*Bulletin Mensuel de l'Observatoire de Montsouris.
*Canadian Entomologist.
*Deutsche Kolonialzeitung.
Entomologist.
Entomologists' Monthly Magazine.
*Geographical Journal.
Geological Magazine.
Science Gossip.
*Johns Hopkins University Circulars.
Journal de Pharmacie et de Chimie.
Journal of Botany.
*Journal of the Chemical Society.
*Journal of the Franklin Institute.
*Journal of the Photographic Society.
*Journal of the Society of Chemical Industry.
London, Edinburgh, and Dublin Philosophical Magazine.
*Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
Petermann's Mitteilungen.
Polytechnic Bibliothek.
*Proceedings of Royal Society of London.
*Proceedings of the Society of Biblical Archæology.
Revue Universelle des Mines.
*Royal Astronomical Society's Monthly Notices.
Sanitary Journal.
Scots Lore.
*Scottish Geographical Magazine.
Zoologist.

QUARTERLY.

Annales des Mines.
Annals of Botany.
Annals of Scottish Natural History.
*Archives Nèerlandaises des Sciences Exactes et Naturelles.
*Bulletin of the American Geographical Society.
Economic Journal.
Forschritte der Mathematik.
Grevillea.
Ibis.
Journal of Anatomy and Physiology.
*Journal of the Anthropological Institute of Great Britain.
*Journal of Manchester Geographical Society.
Journal of the Royal Agricultural Society of England.
Journal of the Royal Microscopical Society.
*Journal of the Royal Statistical Society.
*Journal of the Scottish Meteorological Society.
La Nature.
Mind: a Quarterly Review of Psychology and Philosophy.
Quarterly Journal of Economics.
Quarterly Journal of Geological Society.
Quarterly Journal of Microscopical Science.
Quarterly Journal of Pure and Applied Mathematics.
Reliquary and Illustrated Archæologist.
*School of Mines Quarterly.
*Sociedad Cientifica "Antonio Alzate."
Zeitschrift für Analytische Chemie.

LIST OF MEMBERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW,

FOR 1894-95.

HONORARY MEMBERS.

(Limited to Twenty.)

WITH YEAR OF ELECTION.

FOREIGN.

Rudolph Albert von Kölliker, Würtzburg. 1860
Ernst Heinrich Hæckel, Jena. 1880
Georg Quincke, Heidelberg. 1890

AMERICAN AND COLONIAL.

Robert Lewis John Ellery, F.R.A.S., Victoria. 1874
5 Sir John William Dawson, LL.D., F.R.S., Principal of M'Gill College, Montreal. 1883
Thomas Muir, M.A., LL.D., F.R.S.E., Superintendent General of Education, Cape Colony. 1892

BRITISH.

Sir Joseph Dalton Hooker, K.C.B., K.C.S.I., M.D., D.C.L., LL.D., F.R.S., The Camp, Sunningdale. 1874
Herbert Spencer, care of Messrs. Williams & Norgate, 14 Henrietta street, Covent Garden, London. 1879
Rev. John Kerr, LL.D., F.R.S., Glasgow. 1885
10 Sir George Gabriel Stokes, Bart., M.A., LL.D., D.C.L., F.R.S., M.P., Cambridge. 1887
F. Max Müller, M.A., Professor of Comparative Philology, Oxford. 1889
The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., *Sec.*R.S., London, Terling Place, Witham, Essex. 1890

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

A. S. Herschel, M.A., D.C.L., F.R.S., F.R.A.S., Hon. Professor of Experimental Physics in the Durham College of Science, Newcastle-on-Tyne; Observatory House, Slough, Bucks. 1874
Thomas E. Thorpe, Ph.D., F.R.S., Professor of Chemistry in Royal College of Science, London. 1874
John Aitken, F.R.S., F.R.S.E., Darroch, Falkirk. 1883
Alex. Buchan, M.A., LL.D., F.R.S.E., Secretary to the Scottish Meteorological Society, 122 George street, Edinburgh. 1883
5 James Dewar, M.A., F.R.S., F.R.S.E., M.R.I., Jacksonian Professor of Physics, University of Cambridge, and Professor of Chemistry in the Royal Institution of Great Britain, 1 Scroope terrace, Cambridge. 1883
Stevenson Macadam, Ph.D., F.R.S.E., Lecturer on Chemistry, Surgeons' Hall, Edinburgh. 1883
Joseph W. Swan, M.A., F.R.S., Lauriston, Bromley, Kent. 1883
E. A. Wünsch, F.G.S., Carharrack, Scorrior, Cornwall. 1883
George Anderson, Master of the Mint, Melbourne. 1885
10 William Milne, M.A., B.Sc., F.R.S.E., Department of Public Education, Cradock, Cape Colony, ... 1894

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

* *Denotes Life Members.*

Adam, William, M.A., 235 Bath st. 1876
*Adam, Thomas, 27 Union street. 1892
Adams, William, 28 Ashton terrace, Dowanhill. 1891
Addison, W. H., Superintendent, Deaf and Dumb Institution. 1895
5 Aikman, C. M., M.A., D.Sc., F.R.S.E., F.I.C., F.C.S., 128 Wellington street. 1886
Alexander, D. M., Marionville, Queen's drive. 1887
Alexander, G. W., M.A., 129 Bath street 1893
Alston, J. Carfrae, 27 James Watt st. 1887
Anderson, Alexander, 157 Trongate. 1869
10 Anderson, James, 168 George street. 1890
Anderson, John, 22 Ann street. 1884
Anderson, Robert, 22 Ann street. 1887
Anderson, R. T. R., 618 Gallowgate street. 1889
*Anderson, T. M'Call, M.D., Professor of Clinical Medicine in the University of Glasgow, 2 Woodside terrace. 1873
15*Anderson, William, 284 Buchanan street. 1890
Anderson, W. F. G., 47 Union street. 1878
Annan, J. Craig, 234 Sauchiehall st. 1888
Annandale, Charles, M.A., LL.D., 35 Queen Mary avenue. 1888
Arnot, James Craig, 162 St. Vincent street. 1869
20*Arnot, J. L., 116 West Campbell st. 1890
Arnot, William, City Chambers. 1894
Atkinson, J. B., 10 Foremount terrace, Partick. 1889
Bain, Andrew, 17 Athole gardens. 1890
Bain, Sir James, F.R.S.E., 3 Park terrace. 1866
25 Bain, Robert, 132 West Nile street. 1869
*Baird, J. G. A., M.P., Wellwood, Muirkirk. 1892
Balloch, Robert, Eamont lodge, Dowanhill. 1843
Balmain, Thos., 1 Kew terrace, Kelvinside. 1881
Barbour, T. F., F.C.S., F.I.C., 35 Robertson street. 1891
30 Barclay, A. J. Gunion, M.A., F.R.S.E., High School. 1893
Barclay, A. P., 133 St. Vincent street. 1890
Barclay, George, 6 Colebrooke ter. 1891
Barclay, James, 36 Windsor terrace. 1871
Barrett, Francis Thornton, Mitchell Library. 1880
35 Barr, Archibald, D.Sc., Professor of Civil Engineering and Mechanics, University of Glasgow, Royston, Dowanhill. 1890
*Barr, James, C.E., I.M., F.S.I., 221 West George street. 1883
Barr, Thos., M.D., F.F.P.S.G., 13 Woodside place, W. 1879
Bathgate, William, M.A., 13 Westbourne gardens. 1887
Bayne, A. Malloch, 13 Kelvin drive, Kelvinside. 1878
40 Beatson, George T., B.A. (Cantab.), M.D., 7 Woodside crescent. 1881
Begg, Wm., 636 Springfield road. 1883
Becker, Professor L., The Observatory, Glasgow. 1895

Beilby, George T., F.I.C., St. Kitts, Slateford. 1895
*Beith, Gilbert, 7 Royal Bank place. 1881
45 Bell, Dugald, F.G.S., 27 Lansdowne crescent. 1871
*Bell, Henry, 39 Fitzjohns avenue, Hampstead, London, N.W. 1876
Bell, Sir James, Bart., 101 St. Vincent street. 1877
Bell, Stuart, 41 Clyde place. 1893
Bennett, Robert J., Alloway park, Ayr. 1883
50 Biles, J. H., Professor of Naval Architecture and Marine Engineering, University of Glasgow. 1893
Bilsland, William, 28 Park circus. 1888
Binnie, J., Barassie, Troon. 1877
Black, D. Campbell, M.D., M.R.C.S.E., Professor of Physiology, Anderson's College Medical School, 121 Douglas street. 1872
Black, J. Albert. Duneira, Row. 1869
55 Black, John, 16 Park terrace. 1869
Black, Malcolm, M.D., 5 Canning place. 1880
*Blackie, J. Alexander, 17 Stanhope st. 1881
*Blackie, J. Robertson, 17 Stanhope st. 1881
Blackie, Robert, 17 Stanhope st. 1847
60 Blackie, W. G., Ph.D., LL.D., F.R.G.S., 17 Stanhope street. 1841
*Blackie, Walter W., B.Sc., 17 Stanhope street. 1886
Blair, G. M'Lellan, 2 Lilybank ter. 1869
Blair, J. M'Lellan, Williamcraig, Linlithgowshire. 1869
Blair, Matthew, 11 Hampton Court terrace. 1887
65 Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy, Andersonian Buildings, 204 George street. 1881
*Blyth, Robert, C.A., 1 Montgomerie quadrant. 1885
*Blythswood, The Rt. Hon. Lord, Renfrew. 1885
Borland, William, 142 St. Vincent street. 1895
Borthwick, James D., 3 Balshagray terrace, Partick. 1891
70 Bottomley, James T., M.A., D.Sc., F.R.S., F.R.S.E., F.C.S., Demonstrator in Natural Philosophy, University of Glasgow, 13 University gardens, Hillhead. 1880
Bottomley, Wm., C.E., 15 University gardens. 1880
Bower, F. O., D.Sc., M.A., F.R.S., F.L.S., Regius Professor of Botany in the University of Glasgow, 45 Kersland terrace. 1885
Bower, W. Ackroyd, Govan Ironworks. 1895
Boyd, John, Shettleston Iron-works, near Glasgow. 1873
75 Brier, Henry, M.I.M.E., Scotch and Irish Oxygen Co., Polmadie. 1889
Brodie, John Ewan, M.D., C.M., F.F.P.S.G., 5 Woodside place. 1873
Brown, Alexander, 3 Queen's terrace. 1887
*Brown, Hugh, 5 St. John's terrace, Hillhead. 1887
Brown, James, 76 St. Vincent st. 1876
80*Brown, John, 11 Somerset place. 1881
Brown, Richard, 138 West George street. 1895
Brown, Robert, 19 Jamaica street. 1882
*Brown, Wm. Stevenson, 41 Oswald street. 1886
*Brown, William, 165 W. George st. 1892
85 Browne, Richard, Beechholm, Queen's drive, Crosshill. 1893
Browne, Robert, B.Sc., 45 Washington street. 1893
Brownlie, Archibald, Bank of Scotland, Barrhead. 1880
Brownlie, J. Rankin, L.D.S.(Eng.), 220 West George street. 1892
*Bryce, Charles C., 141 West George street. 1884
90 Bryce, David, 129 Buchanan street. 1872
*Bryce, Robert, 82 Oswald street. 1886
*Buchan, William P., 36 & 38 Renfrew street. 1875
Buchanan, Alex. M., A.M., M.D., Professor of Anatomy, Anderson's College Medical School, 98 St. George's road. 1876
Buchanan, George S., 85 Candleriggs. 1845
95*Buchanan, William, 123 Blythswood drive. 1886
Burnet, John, I.A., 167 St. Vincent street. 1850
Burnet, John James, A.R.I.B.A., 18 University avenue. 1892
Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864

*Caldwell, George B., Scotia Leather Works, Boden street. 1892
100 Callajon, Ventura De, 131 West Regent street. 1886
Cameron, Sir Charles, Bart., M.D., LL.D., Greenock. 1870
Cameron, H. C., M.D., 200 Bath street. 1873
Campbell, Archibald, Springfield quay. 1895
*Campbell, J. A., LL.D., M.P., Stracathro, Brechin. 1848
105*Campbell, James, 137 Ingram st. 1885
*Campbell, John Ferguson, 2 Holborn terrace, N., Kelvinside. 1892

Campbell, John MacNaught, C.E., F.Z.S., F.R.S.G.S., Kelvingrove Museum. 1883
*Campbell, Louis, 3 Eton terrace, Hillhead. 1881
Campbell, Malcolm, 18 Gordon st. 1894
110 Campbell, Thomas, Maryhill Iron-works, 1894
Carlile, Thomas, 23 West Nile st. 1851
Carmichael, Neil, M.D., C.M., F. F. P. S. G., Invercarmel, 23 Nithsdale drive, Pollokshields. 1873
Carver, Thomas A.B., B.Sc., C.E., Heigham, Aubrey road, Hornsey, London, N. 1890
Cassells, John, 62 Glencairn drive, Pollokshields. 1890
115*Cayzer, Charles W., M.P., 109 Hope street. 1886
Chalmers, A. K., M.D., D.P.H. (Camb.), 23 Kersland terrace. 1892
Chalmers, James, I.A., 93 Hope st. 1884
Chalmers, P. MacGregor, F.S.A.Scot., 176½ Hope street. 1891
Cherrie, James M., Clutha cottage, Tollcross. 1876
120*Chisholm, Samuel, 4 Royal ter., W. 1890
*Christie, Henry W., Levenfield house, Alexandria. 1892
Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
Chrystal, W. J., F.I.C., F.C.S., Shawfield Works, Rutherglen. 1882
Church, W. R. M., C.A., 104 West George street. 1885
125 Clapperton, Charles, 175 West George street. 1882
Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
Clark, John, 9 Wilton crescent. 1872
*Clark, William, 125 Buchanan st. 1876
Cleland, A. B. Dick, 15 Newton place. 1871
130*Cleland, John, M.D., LL.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 1884
*Coats, Joseph, M.D., Professor of Pathology in the University of Glasgow, 8 University gardens, *Vice-President.* 1873
*Cochran, Robert, 7 Crown circus, Dowanhill. 1877
Coghill, Wm. C., 263 Argyle street. 1873
Colquhoun, James, LL.D., 158 St. Vincent street. 1876
135 Colville, James, M.A., D.Sc., 14 Newton place. 1885
Combe, James Russell, 257 West Campbell street. 1895
Connell, Wm., 42 St. Enoch square. 1870
Cooke, Louis H., A.R.S.M., 204 George street. 1893

Copland, Wm. R., M.Inst.C.E., F.S.I., 146 West Regent street. 1876
140 Core, Wm, M.D., Medical Superintendent, Barnhill Hospital. 1891
Coste, Jules, French Consulate, 131 West Regent street. 1888
Costigane, John T., Hampton house, Ibrox. 1889
Costigane, William, Clifton hall, Albert drive, Pollokshields. 1890
Coubrough, A. Sykes, Parklea, Blanefield, Strathblane. 1869
145 Coulson, W. Arthur, 57 West Nile street. 1888
Couper, James, Craigforth house, Stirling. 1862
Cowan, M'Taggart, C.E., 27 Ashton terrace, Hillhead. 1876
Craig, T. A., C.A., 139 St. Vincent street. 1886
Crawford, Wm. C., M.A., Lockharton gardens, Slateford, Edinburgh. 1869
150 Cree, Thomas S., 21 Exchange sq. 1869
Crichton, James, 201 Nithsdale road, Pollokshields. 1892
Crosbie, L. Talbot, Scotstounhill, Whiteinch. 1890
Cross, Alexander, M.P., 203 Cromwell road, London, S.W. 1887
Crum, Walter G., Thornliebank. 1895
155 Curphey, Wm. Salvador, 15 Bute mansions, Hillhead 1883
Cuthbert, Alexander A., 14 Newton terrace. 1885
*Cuthbertson, Sir John N., LL.D., 29 Bath street. 1850

Dansken, A. B., 121 West George street. 1877
*Dansken, John, I.M., F.S.I., F.R.A.S., 241 West George street. 1876
160 Darling, Geo. E., 178 St. Vincent st. 1870
Darwin, Harry, St. Andrew's Works, 618 Eglinton street. 1891
Davey, Arthur J., London Road Iron-works. 1895
Deas, Jas., C.E., 7 Crown gardens, Dowanhill. 1869
Dempster, John, 4 Belmar terrace, Pollokshields. 1875
165 Dennison, William, C.E., 175 Hope street. 1876
*Dick, George Handasyde, 136 Buchanan street. 1887
*Dixon, A. Dow, 10 Montgomerie crescent, Kelvinside. 1873
Dixon, Walter, 164 St. Vincent street. 1893
Dobbie, A. B., M.A., University. 1885
170 Dobson, James, Springfield avenue, Uddingston. 1892

Donald, John, Townhead Public School. 1872
Donald, William J. A., 70 Great Clyde street. 1877
Donaldson, James, Gas-works, Cambuslang. 1890
Dougall, Franc Gibb, 167 Canning street. 1875
175 Dougall, John, M.D., C.M., F.F.P.S.G., Professor of Materia Medica, St. Mungo's College, 493 Shields road. 1876
Douglas, Campbell, I.A., F.R.I.B.A., 266 St. Vincent street. 1870
Downie, Robert, jun., Carntyne Dye-works, Parkhead. 1872
Downie, Thomas, Hydepark Foundry. 1886
Duncan, Eben., M.D., C.M., F.F.P.S.G., Queen's Park house, Langside road, *Vice-President.* 1873
180 Duncan, Hugh, M.A., LL.B., 175 West George street. 1895
*Duncan, Robert, Whitefield Works, Govan. 1890
*Duncan, Walter, 7 West George st. 1881
*Dunlop, Nathaniel, 25 Bothwell street. 1870
Dunn, Robert Hunter, 4 Belmont crescent. 1878
185 Dyer, Henry, M.A., D.Sc., C.E., 8 Highburgh terrace, Dowanhill. 1883

Eadie, Alexander, 280 Cathcart rd. 1885
*Edwards, John, Govanhaugh Dye-works, M'Neil street. 1883
Elgar, Francis, LL.D., 113 Cannon street, London, E.C. 1884
*Ellis, T. Leonard, North British Iron-works, Coatbridge. 1888
190 Erskine, Jas., M.A., M.B., L.F.P.S.G., 351 Bath street. 1886
*Ewing, Wm., 62 Buchanan street. 1883

Fairweather, Wallace, C.E., 62 St. Vincent street. 1880
Falconer, Patrick, 33 Hayburn crescent, Partick. 1876
Falconer, Thos., 50 Kelvingrove st. 1880
195 Farquhar, John, 13 Belhaven ter. 1872
Farquhar, Wm. R., 13 Belhaven terrace. 1892
Faulds, W. B., Westfield, Ibrox. 1890
Fawsitt, Charles A., 9 Foremount terrace, Partick. 1879
Fergus, Freeland, M.D., F.F.P.S.G., 203 Bath street. 1887
200 *Ferguson, John, M.A., LL.D., F.R.S.E., Professor of Chemistry, University of Glasgow, *President.* 1869
Ferguson, John Forbes, 138 West George street. 1895
Ferguson, Joshua, M.A., Enfield house, Crosshill. 1895
Ferguson, Peter, 15 Bute gardens, Hillhead. 1866
Ferguson, Thomas, 4 Woodside place, Shettleston. 1883
205 Fergusson, Alex. A., 48 M'Alpine street. 1847
Findlay, Joseph, Clairmont, Winton drive, Kelvinside. 1873
Finlayson, James, M.D., 2 Woodside place. 1873
*Fleming, James, 136 Glebe street. 1880
*Fleming, William James, M.D., 3 Woodside terrace. 1876
210 Fotheringham, T. B., 65 West Regent street. 1889
Foulis, William, C.E., 45 John st. 1870
*Fowler, John, 5 Derby street, Sandyford. 1880
Frame, James, Union Bank of Scotland, 113 King street, Tradeston. 1885
Fraser, Matthew P., 91 W. Regent street. 1887
215 Fraser, Melville, 31 St. Vincent place. 1890
Frazer, Daniel, 127 Buchanan st. 1853
Frew, Alex., C.E., 175 Hope street. 1876
Fullarton, J. H., M.A., B.Sc., Fishery Board Office, Edinburgh. 1886
Fulton, David, Roxburgh villa, Bothwell. 1891
220 Fulton, R. C., 14 Hamilton Park terrace. 1890
Fyfe, Henry B., 115 St. Vincent street. 1892

Gairdner, Charles, LL.D., Broom, Newton-Mearns. 1884
*Gairdner, C. D., C.A., 115 St. Vincent street. 1886
Gairdner, W. T., M.D., LL.D., F.R.S., Professor of Practice of Medicine in the University of Glasgow, 225 St. Vincent street. 1863
225 Galbraith, Peter, 17 Huntly gardens. 1889
Galbraith, Walter M., 7 Holyrood crescent. 1893
Gale, James M., C.E., 45 John st. 1856
Galloway, T. Lindsay, C.E., 43 Mair street, Plantation. 1881
Gardner, Daniel, 36 Jamaica street. 1869
230 *Garrow, James R., 32 Elmbank crescent. 1890
*Garroway, John, 694 Duke st. 1875
Geddes, Wm., 8 Battlefield crescent, Langside. 1846
Gillies, W. D., 17 Royal Exchange square. 1872
Gilfillan, Wm., 129 St. Vincent st. 1881

235 Glaister, John. M.D., F.F.P.S.G., D.P.H.(Camb.), &c., Professor of Medical Jurisprudence and Public Health, St. Mungo's College, 4 Grafton place. 1879
Goldie, James, 40 St. Enoch square. 1883
Goodwin, Robert, 58 Renfield street. 1875
Gourlay, John, C.A., 24 George square. 1874
Gow, Leonard, 19 Waterloo street. 1889
240 Gow, Leonard, jun., 19 Waterloo street. 1884
Gow, Robert, Cairndowan, Dowanhill gardens. 1860
Graham, Alex. M., Rowanlea, 7 St. Andrew's drive, Pollokshields. 1887
Graham, Robert, 108 Eglinton st. 1888
*Graham, William, B.L., 11 Claremont terrace. 1885
245 Gray, Andrew, 30 Bath street. 1889
Gray, James, M.D., 15 Newton terrace. 1863
Greenlees, Alex., M.D., 2 Havelock terrace, Paisley road. 1864
Grieve, John, M.A., M.D., F.R.S.E., c/o W. L. Buchanan, 212 St. Vincent street. 1856
Guthrie, John, 50 M'Culloch st. 1891

250 Halket, George, M.D., F.F.P.S.G., 4 Royal cres., W. 1889
Hamilton, Don., Brandon, Uddingston. 1894
*Hamilton, John, I.A., 212 St. Vincent street. 1885
Harley, George, 29 Burnbank gar. 1891
*Harvie, John, Secretary, Clydesdale Bank, 30 St. Vincent place. 1880
255 Harvie, William, 8 Bothwell terrace, Hillhead. 1888
Hassard, William John, 209 Sauchiehall street. 1895
Hay, Alexander, 63 Reidvale street. 1892
Hedderwick, Maxwell, 22 St. Vincent place. 1892
Henderson, Alex., Barnhill Poorhouse. 1894
260*Henderson, A. P., 20 Newton place. 1880
Henderson, George G., M.A., D.Sc., F.I.C., F.C.S., Professor of Chemistry, Glasgow and West of Scotland Technical College, 204 George street. 1883
Henderson, John, 38 Berkeley st. 1893
*Henderson, John, jun., Meadowside Works, Partick. 1879
Henderson, John, Towerville, Helensburgh. 1890
265 Henderson, Robert, 167 West Regent street. 1885
*Henderson, Wm., 15 Cadogan st. 1873

Hendrick, James, B.Sc., F.C.S., 60 John street. 1893
Hendry, George Scott, 87 Bothwell street. 1895
Henry, R. W., 62 Kelvingrove st. 1875
270 Heys, Zechariah J., South Arthurlie, Barrhead. 1870
Higgins, Henry, jun., 247 St. Vincent street. 1878
Hodge, William, 27 Montgomerie drive, Kelvinside. 1878
Hogg, Robert, 9 Nithsdale drive, Pollokshields. 1865
Honeyman, John, F.R.I.B.A., 140 Bath street. 1870
275 Horton, William, Birchfield, Mount Florida. 1889
Howat, William, 37 Elliot street. 1885
Howatt, James, I.M., 146 Buchanan street. 1870
Howatt, William, I. M., 146 Buchanan street. 1870
Hunt, Edmund, 87 St. Vincent st. 1856
280*Hunt, John, Milton of Campsie. 1881
*Hunter, Wm. S., 30 Hope street. 1889
Hutchison, Peter, 3 Lilybank terrace, Hillhead. 1889

Inglis, John, Pointhouse Shipyard. 1895
Inglis, R. A., Culrain, Bothwell. 1889

285*Jack, William, M.A., LL.D., Professor of Mathematics in the University of Glasgow. 1881
Jamieson, Andrew, F.R.S.E., M.Inst.C.E., M.Inst.E.E., &c., Professor of Electrical Engineering, Glasgow and West of Scotland Technical College, 16 Rosslyn terrace, Kelvinside. 1881
Jenkins, Thomas Wilson, M.A., M.D., 1 Newark drive. 1892
Johnston, David, 160 West George st. 1891
Johnstone, Jas., Coatbridge street, Port-Dundas. 1869
290 Jolly, William, F.G.S., F.R.S.E., Greenhead house, Govan. 1890
Jones, Prof. Henry, The University, Glasgow. 1895

Kay, Wm. E., F.C.S., Gowanbank, Clarkston, Busby. 1887
Kean, James, 32 Scotia street, Garnethill. 1888
Kelly, James K., M.D., F.F.P.S.G., Park villa, Queen Mary avenue, Crosshill. 1889
295 Kelvin, The Right Hon. Lord, LL.D., D.C.L., P.R.S., F.R.S.E., Professor of Natural Philosophy, University of Glasgow, *Hon. Vice-President.* 1846

Kennedy, James, 33 Greendyke street. 1889
Ker, Charles, M.A., C.A., 115 St. Vincent street. 1885
*Ker, Wm., 1 Windsor ter., west. 1874
Kerr, Adam, 175 Trongate. 1887
300 Kerr, Charles James, 40 West Nile street. 1877
Kerr, Geo. Munro, 97 Buchanan street. 1890
Kerr, John G., M.A., 15 India street. 1878
Key, William, 109 Hope street. 1877
King, James, 57 Hamilton drive, Hillhead. 1848
305 King, Sir James, Bart., LL.D., of Campsie, 115 Wellington street. 1855
King, John, Tigh Ruadh, Possilpark. 1895
King, John Y., 142 St. Vincent street. 1893
Kirk, Robert, M.D., Newton cottage, Partick. 1877
Kirkpatrick, Alexander B., 88 St. Vincent street. 1885
310 Kirkpatrick, Andrew J., 179 West George street. 1869
Kirkwood, James, Carling lodge, Ibrox. 1890
Knight, James, M.A., B.Sc., 121 Kenmure street, Pollokshields. 1893
Knox, Adam, 47 Crownpoint road. 1881
*Knox, David J., 19 Renfield street. 1890
315 Knox, John, 58 Bath street. 1883

Laird, George H., 3 Seton terrace, Dennistoun. 1882
Laird, John, Marchmont, Port-Glasgow. 1876
Laird, John, Royal Exchange Sale Rooms. 1879
Lamond, Robert, 8 Marchmount terrace, Kelvinside. 1894
320 Lang, William, F.C.S., Crosspark, Partick, *Vice-President.* 1865
Latta, James, 73 Mitchell street. 1869
*Lauder, James, F.R.S.L., Glasgow, Athenæum. 1892
Lauder, John, 87 Union street. 1894
Leitch, Alexander, 60 Rosebank terrace, Grant street. 1886
325 Leslie, John A., jun., 48 Cadogan street. 1894
*Lindsay, Archd. M., M.A., 87 West Regent street. 1872
Lothian, Alex. V., M.A., 7 Huntly terrace, Kelvinside. 1893
Love, James Kerr, M.D., C.M., 10 Newark drive. 1888
Lundholm, C. O., Nobel's Explosives Factory, Ardeer, Stevenston. 1890

330 M'Ara, Alex., 65 Morrison street. 1888
MacArthur, J. G., Rosemary villa, Bowling. 1874
*MacArthur, John S., 108A Hope street. 1890
M'Callum, Robert, jun., 69 Union street. 1891
*M'Clelland, Andrew Simpson, C.A., 4 Crown gardens, Dowanhill. 1884
335 M'Conville, John, M.D., 27 Newton place. 1870
M'Cracken, James, 5 Bowmont terrace, Kelvinside. 1889
M'Crae, John, 7 Kirklee gardens, Kelvinside. 1876
M'Creath, James, M.E., 208 St. Vincent street. 1874
M'Culloch, Hugh, 154 West Regent street. 1880
340 Macdonald, Archibald G., 8 Park circus. 1869
Macdonald, Thomas, 50 Gibson street, Hillhead. 1869
Macdonald, Thomas F., M.B., C.M., Burgh house, Maryhill. 1889
Macfarlane, Walter, Crosslea house, Thornliebank. 1869
*Macfarlane, Walter, 12 Lynedoch crescent. 1885
345 M'Farlane, Wm., Edina lodge, Rutherglen. 1888
*M'Gilvray, R. A., 129 West Regent street. 1880
M'Gregor, Duncan, F.R.G.S., 37 Clyde place. 1867
M'Gregor, James, 1 East India avenue, London, E.C. 1872
M'Houl, David, Ph.D., Dalquhurn Works, Renton. 1883
350 *Macindoe, Alex., C.A., Ardlui, Helensburgh. 1894
Macintosh, Donald J., M.B., C.M., Western Infirmary. 1894
Macintyre, Dr. John, 179 Bath st. 1895
M'Intyre, Wm., Marion bank, Rutherglen. 1888
M'Kechnie, Robert, 11 Royal Exchange square. 1893
355 M'Kellar, J., 25 Kelvinside terrace. 1893
*M'Kenzie, W. D., 43 Howard street. 1875
*M'Kenzie, W. J., 1 Oakfield ter., Hillhead. 1879
*M'Kendrick, John G., M.D., C.M., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of Institutes of Medicine in the University of Glasgow, 2 Florentine gardens, *Hon. Vice-President.* 1877
Mackinlay, David, 6 Great Western terrace, Hillhead. 1855

360*Mackinlay, James Murray, 4 Westbourne gardens. 1886
M'Kissack, John, 68 West Regent st. 1881
Maclae, A. Crum, 147 St. Vincent st. 1884
M'Laurin, Robert, 347 Gairbraid street, Maryhill. 1895
*Maclay, David T., 169 W. George street. 1879
365 Maclay, W., Eildon villas, Mount Florida. 1893
Maclean, A. H., 8 Hughenden terrace, Kelvinside. 1870
Maclean, Magnus, M.A., F.R.S.E., 8 St. Albans terrace, Hillhead. 1885
MacLehose, James J., M.A., 61 St. Vincent street. 1882
*Macleod, A., 3 Dundas street. 1893
370 M'Lennan, James, 40 St. Andrew's street. 1888
Macnair, D. S., Ph.D., B.Sc., 2 Grosvenor terrace, Glasgow. 1895
Macouat, R. B., 37 Elliot street 1885
Macphail, Donald, M.D., Garturk cottage, Whifflet, Coatbridge. 1877
M'Pherson, George L., 30 Albert road, Crosshill, East. 1872
375 M'Vail, D. C., M.B., Professor of Clinical Medicine, St. Mungo's College, 3 St. James' terrace, Hillhead. 1873
Machell, Thomas, 1 Burnbank terrace, 1886
Main, Robert B., 56 Dalziel drive. 1885
Mann, John, C.A., 188 St. Vincent street, *Treasurer*. 1856
Mann, John, jun., M.A., C.A., 188 St. Vincent street. 1885
380 Manwell, James, The Hut, 4 Albert drive, Pollokshields. 1876
Marshall, T. Rhymer, D.Sc., Professor of Chemistry in St. Mungo's College, 11 Woodside crescent. 1894
Martin, William, 116 St. Vincent street. 1892
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Martin, W. C., 342 Argyle street. 1889
385 Marwick, Sir J. D., LL.D., F.R.S.E., 19 Woodside terrace. 1878
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Mavor, Alfred E., Victoria mansions, 32 Victoria street, London, S.W. 1890
Mavor, Henry A., 57 West Nile street. 1887
Mavor, James, 63 Bank street, Hillhead. 1885
390 Mavor, Samuel, 3 Elmbank cres. 1890
Mayer, John, Strathview, Cathkin road, Langside, *Secretary*. 1860
Mechan, Arthur, 60 Elliot street. 1876
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Meikle, Andrew W., M.A., Viewfield house, Pollokshields. 1890
395 Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
*Menzies, Thos. J., M.A., B.Sc., F.C.S., 211 Crown street, S.S. 1887
Menzies, William Crawford, City Improvement Trust, 34 Trongate. 1895
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Miller, A. Buchanan, 13 North Claremont street. 1891
400 Miller, A. Lindsay, 122 Wellington street. 1878
*Miller, Arch. Russell, 28 Lilybank gardens, Hillhead. 1884
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*Miller, George, Winton drive, Kelvinside. 1881
Miller, G. J., Frankfield, Shettleston. 1888
405 Miller, John (Messrs. James Black & Co.), 23 Royal Exchange square. 1874
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*Miller, Thos. P., Cambuslang Dyeworks. 1864
Milligan, Thomas R., 22 Arlington street. 1892
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410 Mirrlees, James B., Redlands, Kelvinside. 1869
*Mirrlees, William J., 42 Aytoun road, Pollokshields. 1889
*Mitchell, George A., 63 Bath street. 1883
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*Moffatt, Alexander, 23 Abercromby place, Edinburgh. 1874
415 Mollison, James, 6 Hillside gardens, Partick. 1889
*Mond, Robert Ludwig, B.A. (Cantab), F.R.S.E., 20 Avenue road, Regent's park, London, N.W. 1890
*Monteith, Robert, Greenbank, Dowanhill gardens. 1885
Moore, Alexander, C.A., 209 West George street. 1869
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420 Morrice, Jas. A., 1 Athole gardens place. 1883
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*Muir, Allan, 183 George street. 1881
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425 Muir, Sir John, Bart., 22 West Nile Street. 1876
*Muirhead, Andrew Erskine, Cart Forge, Crossmyloof. 1873
Muirhead, James, 10 Doune gardens, Kelvinside. 1887
*Muirhead, Robert F., M.A., B.Sc., 59 Warrender Park road, Edinburgh. 1879
Munro, Daniel, F.S.I., 10 Doune terrace, Kelvinside. 1867
430 Munro, J. Pearson, M.B., C.M., 69 Bank street, Hillhead. 1893
Munsie, George, 1 St. John's ter., Hillhead. 1871
Munsie, Robert George, 10 Berkeley terrace, West. 1883
Murdoch, George, 40 St. Vincent pl. 1894
*Murdoch, Robert, 19 Commerce st. 1880
435 Murdoch, Thomas, 50 Charles st. 1892
*Murray, David, LL.D., 169 West George street. 1876
Murray, John Bruce, 24 George square. 1890
Murray, A. Erskine, Sheriff-Substitute of Lanarkshire, Sundown, Montgomerie drive. 1881
Murrie, James, 264 St. Vincent st. 1892

440 Napier, Alex., M.D., F.F.P.S.G., Rose Bank, Queen Mary avenue, Crosshill. 1886
Napier, James, 15 Prince's square, Strathbungo. 1870
*Napier, John, 23 Portman square, London. 1846
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445 *Newlands, Joseph F., 28 Renfield st. 1883

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Osborne, Robert, 3 Montgomerie crescent. 1890

450 Park, James, 51 Millburn street. 1877
Park, Robert, M.D., 40 Grant st. 1894
*Parker, John Dunlop, C.E., 146 West Regent street. 1889
*Parnie, James, F.S.I., 32 Lynedoch street. 1874
*Paterson, Robert, C.A., 28 Renfield street. 1881
455 Paton, James, F.L.S., Corporation Galleries, and Kelvingrove Museum. 1876
Patrick, Joseph, M.A., C.A., 203 West George street. 1893
Patterson, T. L., F.C.S., at John Walker & Co.'s, Greenock. 1873
Petrie, Alexander, I.A., 134 Wellington street. 1885
Pirie, John, M.D., 26 Elmbank cres. 1877
460 *Pirrie, Robert, 9 Buckingham ter. 1875
*Pollock, R., M.B., C.M., F.F.P.S.G., Laurieston house, Pollokshields. 1883
Pride, David, M.D., Townhead House, Neilston. 1887
Prince, Edward E., B.A. (Cantab), F.L.S. 1892
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465 *Provan, James, 40 West Nile st. 1868
Provand, A. D., M.P., 8 Bridge street, London, S.W. 1888

Raalte, Jacques Van, 103 West George street. 1884
Ramsay, Robert, M.D., L.R.C.S.E., Lochwinnoch. 1881
Ramsey, Robert, 14 Park terrace. 1889
470 Rankine, David, C.E., 5 West Regent street. 1875
Rattray, Rev. Alex., M.A., Parkhead parish, 4 Westercraigs, Dennistoun. 1879
Rattray, William A., 233 Hope st. 1890
Reid, Andrew, Houston place, S.S. 1875
Reid, David, 16 Cambridge street. 1887
475 *Reid, Hugh, Belmont, Springburn. 1880
Reid, James, 15 Montgomerie cres. 1889
Reid, Thos., M.D., 11 Elmbank st. 1869
Reid, William, M.A., 51 Grant st. 1881
*Reid, William L., M.D., Professor of Midwifery, Anderson's College Medical School, 7 Royal crescent, West. 1882
480 Reith, Rev. George, M.A., D.D., Free College Church, 37 Lynedoch st. 1876
Renton, James Crawford, M.D., L.R.C.P.&S.Ed., 1 Woodside terrace. 1875
Rey, Hector, B.L., B.Sc., 2 Vinicombe street, Hillhead. 1889
Richmond, Thos., L.R.C.P.E., 2 West Garden street. 1887
Ritchie, George, Parkhead Forge and Steel Works. 1890
485 Robertson, John, Woodside school, Endcliffe, Langside, *Librarian.* 1860
Robertson, J. M'Gregor, M.A., M.B., C.M., 26 Buckingham ter., Hillhead. 1881
Robertson, Robert A., 8 Park street, East. 1877
Robertson, Robert H., Clyde bank, Rutherglen. 1888
Robertson, William, C.E., 123 St. Vincent street. 1869
490 *Rogers, John C., 224 St. Vincent st. 1888
Rose, Alexander, Richmond house, Dowanhill. 1879

*Rose, Charles A., 1 Belhaven cres. 1889
Ross, David, M.A., B.Sc., LL.D., E.C. Training College. 1888
Ross, Henry, 7 Park quadrant. 1876
495 *Ross, John, 9 Westbourne gardens. 1885
Ross, John Munn, C.A., 115 Wellington street. 1894
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Rottenburg, Paul, 21 St. Vincent place. 1872
Rowan, David, 22 Woodside place. 1863
500 Rowan, W. G., 234 West George street. 1881
Rundell, R. Cooper, Underwriters' Room, Royal Exchange. 1877
Russell, James B., B.A., M.D., LL.D., 3 Foremount terrace, Partick, *Hon. Vice-President.* 1862

Salmon, W. Forrest, F.R.I.B.A., 197 St. Vincent street. 1870
Sawers, Wm. D., Assoc. I.C., 7 Buckingham street, Hillhead. 1894
505 Sayers, William Brooks, 57 West Nile street. 1890
Schmidt, Alfred, 508 New City road. 1881
Scott, Alex., 2 Lawrence place, Dowanhill. 1871
*Scott, D. M'Laren, 2 Park quad. 1881
Scott, John, 140 Douglas street. 1891
510 Scott, John, 245 Sauchiehall st. 1892
Scott, Robt., I.M., 115 Wellington street. 1884
Seligmann, Hermann L., 24 George square. 1850
Sexton, A. Humboldt, F.C.S., F.I.C., F.R.S.E., Professor of Metallurgy, Glasgow and West of Scotland Technical College, 204 George street. 1892
Shields, Thomas, M.A., Royal Indian Engineering College, Cooper's hill, Staines. 1890
515 Simons, Michael, 206 Bath street. 1880
Sinclair, Alexander, Ajmere lodge, Langside. 1883
Sloane, F. N., C.A., 187 West George street. 1893
Smart, William, M.A., LL.D., Nunholm, Dowanhill. 1886
Smellie, George, I.M., 167 St. Vincent street. 1880
520 *Smellie, Thos. D., F.S.I. 209 St. Vincent street. 1871
Smith, Dr. Alex. Muir, 59 Sardinia terrace, Hillhead. 1895
Smith, D. Johnstone, C.A., 149 W. George street. 1888
Smith, Francis, Ashfield, Bothwell. 1875
Smith, Harry J., Ph.D., 6 South Hanover street. 1877
525 Smith, Hugh C., 55 Bath street. 1861
Smith, James, LL.D., St. Peter's Lodge, Uddingston. 1892
*Smith, J. Guthrie, 54 West Nile street. 1875
*Smith, Robert B., Bonnybridge, Stirlingshire. 1884
Snodgrass, James, F.C.S., 2 Keir terrace, Pollokshields. 1878
530 Snodgrass, William, M.A., M.B., C.M., Muirhead Demonstrator of Physiology, University of Glasgow, 11 Victoria crescent, Dowanhill. 1890
*Somerville, Alexander, B.Sc., F.L.S., 4 Bute Mansions, Hillhead street, Hillhead. 1888
Sorley, Robert, 3 Buchanan st. 1878
Spencer, Charles L., Edgehill, Kelvinside. 1891
Spencer, J. J., Edgehill, Kelvinside. 1895
535 Spens, John A., 169 W. George street. 1879
*Spiers, John, 493 Great Western road, Hillhead. 1885
Stanford, Edward C. C., F.C.S., Glenwood, Dalmuir, Dumbartonshire. 1864
*Steel, William Strang, Philiphaugh, Selkirk. 1889
*Stephen, John, Domira, Partick. 1880
540 *Steven, Hugh, Westmount, Montgomerie drive. 1869
Steven, John, 32 Elliot street. 1875
*Stevenson, D. M., 12 Waterloo street. 1889
*Stevenson, Jas., F.R.G.S., 23 West Nile street. 1870
Stevenson, John, C.E., 208 St. Vincent street. 1885
545 Stevenson, John, 12 Victoria road, Lenzie. 1892
Stevenson, Wm., 21 Clyde place. 1888
Stewart, Andrew, 41 Oswald street. 1887
Stewart, Archibald, Marnock villa, Queen's drive, Crosshill. 1892
Stewart, David, 3 Clifton place. 1856
550 Stewart, James Reid, 30 Oswald street. 1845
Stewart, John, Western Saw Mills. 1877
Stobo, Thomas, Somerset house, Garelochhead. 1884
Stoddart, James Edward, Howden, Mid-Calder, N.B. 1872
*Strain, John, C.E., 154 West George street. 1876
555 *Sutherland, David, Royal Marine Hotel, Nairn. 1880
*Sutherland, John, Great Western Hotel, Oban. 1880
Sutherland, J. R., C.E., 45 John street. 1884

Swan, Charles C., 15 Rose street, Garnethill. 1891

Tatlock, John, F.I.C., 13 Parkgrove terrace, West, Sandyford. 1875
560 Tatlock, Robt. R., F.R.S.E., F.I.C., F.C.S., 156 Bath street. 1868
Taylor, Benjamin, F.R.G.S., 10 Derby crescent, Kelvinside. 1872
Teacher, Adam, 14 St. Enoch sq. 1868
Teague, Francis, M.I.E.E., Electric Lighting Station, Coatbridge. 1894
Tennant, Sir Charles, Bart., 195 West George street. 1868
565 Tennent, Gavin P., M.D., 159 Bath street. 1875
Thomas, Moses, M.D., Superintendent, Royal Infirmary. 1890
Thomson, David, I.A., F.R.I.B.A., 2 West Regent street. 1869
Thomson, George C., F.C.S., 23 Kersland terrace, Hillhead. 1883
Thomson, Gilbert, M.A., C.E., 75 Bath street. 1885
570 Thomson, Graham Hardie, 2 Marlborough terrace, Kelvinside. 1869
*Thomson, James, F.R.I.B.A., 88 Bath street. 1886
Thomson, James M., Glen Tower, Kelvinside. 1892
Townsend, C. W., Crawford street, Port-Dundas. 1890
Tullis, David, St. Ann's Leather Works, Bridgeton. 1894
575 *Tullis, James Thomson, Anchorage, Burnside, Rutherglen. 1883
*Turnbull, John, jun., M.I.M.E., 18 Blythswood square. 1883
Turner, George A., M.D., 1 Clifton place, Sauchiehall street. 1883
Turner, William, Rachen house, Helensburgh. 1875

Ure, William P., Regent Mills, Sandyford. 1893

580 Verel, Wm. A., Fairholm, Larkhall. 1883

Walker, Adam, 35 Elmbank cres. 1880
*Walker, Archibald, B.A. (Oxon.), F.C.S., 8 Crown ter., Dowanhill. 1885
Walker, Malcolm M'N., F.R.A.S., 7 Westbourne ter., Fort Matilda, Greenock. 1853
*Wallace, Hugh, Bank of Scotland, 544 St. Vincent street. 1879
585 *Wallace, Wm., M.A., M.B., C.M., 25 Newton place. 1888
Wallace, William, M.A., Central Higher Grade School, Leeds. 1890
Warren, John A., C.E., 115 Wellington street. 1887
Watkinson, Wm. H., Whit. Sch., M.Inst.Mech.E., Professor of Steam and Steam Engines in the Glasgow and West of Scotland Technical College. 1893
Watson, Archibald, 5 Westbourne terrace. 1881
590 Watson, James, 25 Sandyford pl. 1873
*Watson, John, 205 West George street. 1886
Watson, Joseph, 225 West George street. 1882
*Watson, J. Robertson, M.A., Professor of Chemistry, Anderson's College Medical School. 1891
*Watson, Thomas Lennox, I.A., F.R.I.B.A., 166 Bath street. 1876
595 *Watson, Sir William Renny, 16 Woodlands terrace. 1870
Welsh, Thomas M., 3 Prince's gardens, Dowanhill. 1883
Wenley, James A., Bank of Scotland, Edinburgh. 1870
Westlands, Robert, 4 Dixon street. 1869
Whyte, A. C., L.D.S., 42 Dundas street. 1892
600 Whitson, Alexander, jun., 7 Windsor quadrant, Kelvinside. 1893
*Whitson, Jas., M.D., F.F.P.S.G., 13 Somerset place. 1882
*Whitelaw, Thomas N., 87 Sydney st. 1892
Whytlaw, R. A., 1 Windsor quadrant, Kelvinside. 1885
Widmer, Justus, 21 Athole gardens. 1887
605 Wield, John, 9 Barns street, Ayr. 1895
Williams, A. M., M.A., 13 Annfield terrace, W., Partick. 1895
Williamson, John, 65 West Regent street. 1881
Wilson, Alex., Hydepark Foundry, 54 Finnieston street. 1874
Wilson, David, Carbeth, by Killearn. 1850
610 Wilson, John, C.E., 154 West George street. 1895
Wilson, Robert, Glasgow Water Trust, City Chambers. 1893
Wilson, William, Virginia buildings. 1881
Wilson, William, Lord Carlisle's School, Bulmer, York. 1889
Wilson, W. H., 21 Hope street. 1881
615 Wingate, Arthur, 10 Prince's gardens, Dowanhill. 1882
*Wingate, John B., 7 Crown terrace, Dowanhill. 1881
Wingate, P., 14 Westbourne ter. 1872
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Wood, James, M.A., Glasgow Academy. 1885
620 Wood, James, 28 Royal Exchange square. 1886
Wood, Wm. Copland, Turkey-red Works, Alexandria. 1883

Wood, W. E. H., 40 Candleriggs. 1891
*Wood, Wm. Jas., 38 Cochrane st. 1893
Woodburn, J. Cowan, M.D., 197 Bath street. 1869
625 Wright, Robert Patrick, Glasgow and West of Scotland Technical College. 1895

Yellowlees, D., M.D., LL.D., Physician-Superintendent, Gartnavel. 1881
Young, John, 2 Montague terrace, Kelvinside. 1885
Young, John, 88 Renfield street. 1881
*Young, John, jun., M.A., B.Sc., 38 Bath street. 1887
630*Young, Thos. Graham, Westfield, West Calder. 1880
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